

Investigating nutritional and lifestyle factors associated with dietary
habits of children and young adults (university students) using a
mixed methods approach

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Abstract

Obesity has become increasingly prevalent over recent years, and is now recognised as a global public health issue. Preventing obesity during early childhood is important as obese children are also more likely than non-obese peers to be overweight or obese in both adolescence and adulthood. Evidence has shown that the weight of a child at five-years-old is a good predictor of future weight and health status, having long-term effects on both mortality and morbidity. In addition strong evidences that 79% of children who are obese in their early teens are likely to remain obese as adults. The aetiology of obesity is complex and multi-faceted, and many factors are known to contribute to its development- such as diet, activity level, individual biology/genetics, societal influences and individual psychology. Dietary factors that create a positive energy balance have been shown to aid in the development of excess adiposity, partially from the consumption of energy-dense diets, which are thought to be low in fruit, vegetables, and dairy products. Therefore, the promotion of healthy dietary habits is required in children and adults to establish healthy dietary intakes and reduce the likelihood of developing obesity in future years. The aim of this thesis was to investigate the dietary habits of children and young adults required to maintain a healthy weight. The systematic review evaluated the use of social network in weight loss interventions among university students and showed significant BMI reduction using social network sites (n=6). Findings from this were used to design focus group discussions which explored the eating behaviours and experiences of (n=42) university students living away from home and identified 3 key themes which influenced dietary choices and eating behaviours: *nutritional awareness and knowledge*, *personal factors* and *physical factors* and suggested the use of social networks as a method of providing nutritional advise to young adults. Both the systematic review and focus groups were used to design a randomised control trail to test the use of Facebook at delivering nutritional

education and increase fruit and vegetable consumption. Results showed that consumption of FV increased in both intervention groups, however Facebook was insufficient to enhance the effect on FV consumption. Following on from this finding observational data (HAPO) was used to assess dietary intake of young children to investigate dietary habits at this early age and associations with the development of obesity. Dietary patterns were used and identified 3 main patterns: processed, junk and healthy, showing that children who consumed 'junk dietary pattern' which contained more sweets, chocolate, confectionary and less fruit and vegetables had higher BMI than those consuming healthy and processed dietary patterns. This finding led to more in depth nutritional analysis to investigate these diets in relation to carbohydrates intake and associations with BMI and in addition to identify the major sources of sugars and their contribution to energy intake in the diets of children . In conclusion, the research presented in this thesis provides evidence to literature that: that the diets of children and young adults are generally not meeting the healthy eating guidelines with respect to fruit and vegetables intake, in addition providing free fruit and vegetables increased consumption, While Facebook was not effective and had no impact of changing dietary intake. Dietary assessment using principle component analysis identified 3 dietary patterns: processed, junk and healthy. In addition children who consumed 'junk dietary pattern' had higher BMI than those consuming healthy and processed dietary patterns. Sugar-sweetened beverages were identified as the major source of FS's, however this study did not provide evidence that dietary carbohydrates including free sugars increased the risk of childhood obesity.

Abbreviations

ALSPAC= Avon longitudinal study of pregnancy and childhood

ANOVA= Analysis of Variance

BMR = basal metabolic rate

BMI = body mass index (kg/m^2)

Dietary fibre (DF)

Glycaemic index (GI)

Glycaemic load (GL)

EAR= estimated average requirement

EER= estimated energy requirement

EER: EI = Estimated energy requirement: energy intake ratio

EI: BMR = Energy intake: Basal Metabolic Rate

FD= food diary

4DFD= 4 day food diary

FFQ= food frequency questionnaire

FB= Facebook

FV= fruit and vegetables

F&V group = Fruit and vegetables group

F&V + FB group= Fruit and vegetables plus Facebook group

Free sugars (FSs)

HAPO= Hyperglycaemia and adverse pregnancy outcome study

IOM = Institute of Medicine (United States of America)

KMO= Kaiser Meyer Olkin statistical test

OR= over-reporter

PCA = Principal components analysis

Scientific Advisory Committee on Nutrition (SACN)

Sugar- sweetened beverages (SSBs)

SPSS = statistical package for social sciences

The World Health Organisation (WHO)

UR= under reporter

vit= Vitamin

WHO = World Health Organisation

Note to access contents

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The following part was conducted as a part of the PhD

Chapter 1 General introduction

I completed the literature search and write up. AJ Hill and AM Gallagher critically reviewed this chapter.

Chapter 2 systematic review

I conducted a systematic search of the literature, data extraction, assessing risk of bias and identifying behaviour change tool. AJ Hill and AM Gallagher critically reviewed all the steps and assisted in assessing risk of bias and extracting the data.

Chapter 3

I obtained ethical approval and conducted the study and collection of data, transcription of focus group recordings, statistical analysis, and interpretation of results and write up. AJ Hill and AM Gallagher critically reviewed the work and provided guidance.

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I obtained ethical approval and conducted the study and collection of data, statistical analysis, and interpretation of results and write up. AJ Hill and AM Gallagher critically reviewed the work and provided guidance. Blood samples analysis was conducted in the laboratory of the school of public health, Queen`s university by Dr Jayne Woodside

Chapter 5

I conducted statistical analysis, interpretation of results and write up. AJ Hill and AM Gallagher critically reviewed the chapter.

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Chapter 7

I completed the discussion and write up. AJ Hill and AM Gallagher critically reviewed the chapter.

Chapter 1

Introduction and thesis outline

Obesity in children and adults

Definition of obesity

Obesity was defined by The World Health Organization (WHO) in 2006 as being ‘abnormal or excessive fat accumulation that may impair health’. Body weight is generally assessed by calculating Body Mass Index (BMI), which is a measure of (weight for height) where weight in (kg) is divided by height in metres². Obesity is defined in the adult population and categorised as BMI $\geq 30.0\text{kg/m}^2$ and overweight as a BMI 25.0-29.9kg/m² (WHO, 1998).

In children obesity is defined as having a BMI $\geq 95^{\text{th}}$ percentile ($>+2$ Standard Deviations (SDs)) for children of the same age and sex (Centres for Disease Control and Prevention, 2015) and generally plotted using centiles lines and the 1990 British Growth Reference chart in the UK (Cole et al., 1995). It is then converted to BMI z-scores which are indicative of how many SDs a child’s BMI is above or below the average (Must and Anderson, 2006). The WHO BMI z-score cut-offs classify $<-2\text{SDs}$ as underweight, $-2 - 0.99\text{SD}$ ’s as healthy, $>1 - <2\text{SDs}$ as overweight and $>+2\text{SDs}$ as obese (WHO, 2017). Children with a BMI between the 85th-95th percentile for age and gender are considered overweight, and those with a BMI $>95^{\text{th}}$ percentile are considered obese (Lustig & Weiss 2008).

Aetiology determinants and risk factors of obesity

Childhood obesity is a complex health issue, with evidence suggesting that there are numerous causative factors. The Foresight Report suggests that obesity is a multifactorial disease influenced by genetics, environmental, lifestyle and behavioural factors (Government Office for Science, 2007). Whilst the genetic predisposition to childhood obesity is well documented, evidence reports that 90% of cases are owing to environmental influences (WHO, 2017). Children currently live in an ‘obesogenic’ environment characterised by large portion sizes, increased availability and marketing of energy dense foods high in fat, salt and sugar (Barquera et al. 2018). This, in combination with physical inactivity favours energy imbalance and

subsequent weight gain (Dev et al. 2013). Obesity is caused by an imbalance of energy intake and expenditure and this discrepancy is directly related to the dietary behaviours and levels of physical activity of a particular individual (Hill et al., 2012).

Evidence identifies dietary intakes as important in obesity prevention as they are modifiable. Obesity has been identified as a risk factor for obesity in adolescence and adult life (Reilly et al., 2003; Wardle et al., 2006). Children of obese mothers have more probability of becoming obese compared to children of healthy weight mothers (Fuemmeler et al., 2013).

Obesity results due to an imbalance in energy imbalance for a prolonged period between energy consumed and expended, creating a surplus that results in excess body weight. The UK Foresight report has identified over 100 factors that can lead to an increased energy balance, with many relating to dietary intake (Butland 2007). The development of obesity involves interaction between more than 100 different many factors including environmental, socioeconomic, and genetic factors. (Hruby & Hu, 2015; Kremers et al., 2006) which either directly or indirectly affect the energy balance of an individual (Butland et al, 2007). Sedentary behaviour, physical inactivity, large portion sizes and energy dense foods are some of these factors. This report produced a map of seven main factors influencing the development of obesity (see figure 1.1). These factors are:

Biology environment: the impact of the genetics of a person on their predisposition to obesity, level of satiety and resting metabolic rate.

Activity environment: the impact of the environment of a person on participation in physical activity (PA).

Physical activity: the habitual physical activity of a person defined in type, intensity and amount of PA.

Societal influences: the impact of wider society like media, peers and cultural factors on PA and food consumption.

Individual psychology: the impact of the psychology of a person on food choice and PA habits.

Food environment: the effects of a person's food environment on food consumption, such as healthier food options being available or energy dense options, fast food restaurants near home.

Food consumption: food habitually consumed by a person defined in type, amount and frequency.

Food consumption: the type, amount and frequency of food habitually consumed by individual.

However, the exact mechanisms of the development of obesity are not well understood due to the multitude of the involved influencers, such as environment, diet composition, lifestyle habits and various other factors, including socioeconomic aspects (Sahoo et al., 2015).

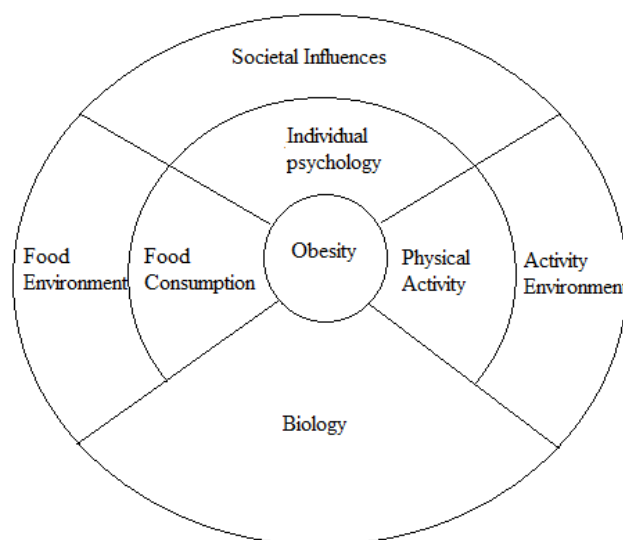


Figure 1.1: Foresight systems Map, 2007 (Foresight report, 2007)

Overweight and obese children have an increased risk of developing chronic diseases, such as hypertension, dyslipidemia, type-2 diabetes, heart disease, gallbladder disease, osteoarthritis, sleep apnoea, respiratory problems, and certain cancers (WHO 2010). In addition to negative health outcomes later in life, overweight or obese childhood may also have physiological impacts at the time, such as social exclusion, low-self-esteem, or depression (Lobstein *et al.* 2004). Even in the absence of any known chronic diseases, higher body mass index (BMI) is positively correlated with increased risk of mortality and that risk is directly proportional to the extent of the excess body weight. Non-smoking individuals with the highest BMI are at nearly three times the risk of mortality when compared to their normal weight counterparts (Di Angelantonio *et al.*, 2016).

Obesity is now the most common problem of childhood and adolescence in the developed world and in the majority of developing countries its prevalence has now overtaken that of underweight (Reilly, 2006). Tackling obesity at an early age should be paramount in modern healthcare as research shows that about 30% of obese children will continue to be obese in adulthood (Simmonds *et al.*, 2016).

In a recent systematic review it was found that cardiovascular disease can be independently predicted by childhood obesity (Umer *et al.*, 2017). Furthermore, anxiety, depression and a poorer quality of life are more likely in obese children compared to their normal weight counterparts as it is indicated by evidence that psychological health is impacted by childhood obesity (Sahoo *et al.*, 2015). Strong evidence indicates that obese children are likely to remain obese as they grow up and that coronary heart disease, stroke, malignancy and untimely death are some of the serious health consequences they are likely to encounter (Sahoo *et al.*, 2015). In light of these findings, identifying the risk factors for obesity is vital in order to prevent the epidemic progressing.

Childhood and adolescent obesity are well-established predictors of many lifestyle-associated diseases which will likely affect these individuals later in their adult life (Llewellyn et al., 2016). Moreover, the adverse effects of obesity typically associated with older age are increasingly reported in young adults. There is a growing body of evidence suggesting that the formation of atheroma plaque deposits in arterial walls which leads to arteriosclerosis, begins as early as late teenage years and could affect up to half of this age group (Kotsis et al., 2016). Furthermore, the prevalence of obesity might be substantially underestimated due to unreliability of most common surrogate measures such as BMI or waist circumference (Reilly, Kelly and Wilson., 2010). It has recently been suggested that excessive adiposity remains unidentified in over a quarter of children who have been assessed using these methods (Javed et al., 2015).

As with the adult population, childhood and adolescence overweight and obesity are significantly inversely correlated to the socioeconomic position (SEP) of an individual, with most striking disparities being observed in developed countries (Shrewsbury and Wardle, 2008). Furthermore, the gap between affluent and deprived households are reported to be widening despite numerous public health initiatives aimed at tackling the issue (Stamatakis, Wardle and Cole, 2010). This is supported by a recent study in UK which showed that children from disadvantaged backgrounds had significantly higher rates of obesity and overweight than children from high-income families (Stamatakis et al., 2005). Towards the end of the last century there was a significant difference between the prevalence of obesity in boys depending on their socio economic position but these gaps are widening for both genders and all categories of excess body weight (Stamatakis et al., 2005). Immigrant populations often have lower socioeconomic position than the general population due to language difficulties as well as the educational and cultural barriers. Indeed, a recent study of North African immigrants to Europe

found that children of that heritage, particularly girls, have considerably higher rates of overweight and obesity when compared to the native children (Gualdi-Russo, 2014). Similarly evidence in the immigrant home countries concluded that the spread of an increasingly westernised diet, rather than cultural differences, could be responsible for this trend. Gualdi-Russo, 2014). The most dramatic example of the impact of obesity and overweight on ethnic minority comes from the U.S. Hispanic population, where the rates of these conditions amount to 42.4% and 77.1%, respectively (Holub et al., 2013). Similar trends are observed for Native American populations in the U.S. (Schell and Gallo, 2012).

Prevalence of Obesity

The prevalence of obesity has increased in both children and adults in recent decades and it is now one of the main public health concerns in affluent Western countries and increasingly, in developing parts of the world (Popkin, Adair and Ng, 2012). In the early 1970s, less than 10% of British children were overweight and less than 2% were classified as obese (Chinn and Rona, 2001). More recent statistics reveal that one in five children are now overweight or obese (Public Health England (PHE), 2016). Global statistics show that 340 million infants and young children were overweight or obese in 2016, indicating that the United Kingdom is not alone in this epidemic (The World Health Organisation (WHO), 2017). The global prevalence of obesity and overweight in adults has been steadily increasing and was estimated to be 29.3% in 1980 compared to 37.45 % in 2013 (Ng et al., 2014). In developed countries such as NI, 27% of those aged 16 and over are obese and a further 36% are overweight, making a total of 63% who are either overweight or obese, while 8% of children aged 2-10 and 7% of children aged 11-15 as being obese according to the Health Survey Northern Ireland in 2016/17. Similarly, the U.S., the prevalence of adult obesity is close to 35% and, while the rate of this increase appears to be plateauing, it is still expected to reach 50% by 2030 (Ogden et al., 2014).

The increase is due to the rising rates of childhood and adolescence obesity which affects nearly 17% of individuals between the ages of 2 and 19 years.

Although previous studies have shown that overweight and obesity are increasing more rapidly in adults than in younger age groups, the gap is closing in most countries regardless of their level of development and relative wealth (Popkin et al., 2006). In fact, the rates of increase in prevalence of childhood and adolescence obesity and overweight are now similar in both developed and developing countries. In 1980, the prevalence was 16.5% and 8.2% for developed and developing countries, respectively. The prevalence had risen to 23.2% and 13.1% by 2013 which is a 47% increase in childhood and adolescent obesity (Ng et al., 2014). During the same period, the prevalence of obesity and overweight for the adult population has risen by 27.5%. This supports the prediction that soon the incidence of obesity and overweight within the child and adolescent populations will equal that seen in the adult population.

Even in some developing countries, where malnutrition was and still is a severe problem, and where overweight or obesity were non-existent until very recently, the prevalence of childhood and adolescent obesity and overweight has risen as dramatically as by 400% (Abarca-Gómez et al., 2017). Interestingly, the trend of adult women being more affected than men is reversed in children and young adults where boys are typically more likely to be obese or overweight than girls (Ogden et al., 2012). Evidence has also shown that the weight of a child at five-years-old is a good predictor of future weight and health status, having long-term effects on both mortality and morbidity (Dietz 1998; Must & Strauss 1999; Weng *et al.* 2012).

This thesis will focus on investigation of nutritional and lifestyle factors associated with dietary habits of two stages of the lifecycle (children and young adults) required to prevent obesity.

Nutritional considerations in the development of obesity

Dietary factors that create a positive energy balance in children have been shown to contribute to the development of excess adiposity. Consumption of energy-dense foods, which are low in fruit, vegetables, and dairy products (Gibson & Wardle 2001; Ledikwe *et al.* 2006; Güngör 2014) and in addition high energy intake and energy density have all been shown to contribute to obesity, however, no single dietary factor has been determined the primary cause (Langley-Evans 2015). Beyond overall high energy intake evidence is inconclusive as to the role of specific combinations of macronutrients with excess adiposity (McGloin *et al.* 2002; Wadden *et al.* 2012; Papandreo *et al.* 2016).

Energy Intake and Macronutrient Composition

Energy -rich diets are considered low in fruit, vegetables, and high in fat and sugary foods and create a positive energy balance resulting in the development of additional adiposity (Koyuncuoğlu, 2014). The average EI reported in the National Diet and Nutrition Survey (NDNS) (2016) for 4-6-year-old children living in the United Kingdom (UK) was 5858-6360 kJ/day. However, Public Health England (2016) recommended children of this age consume 5766-6201 kJ/day, indicating children within the UK are consuming more energy than required. However, a lack of consistency of results between studies arise because of varying focus on overall energy intake and macronutrient compositions. Investigating the significance of dietary quality and dietary patterns is becoming more commonly reported (McGloin *et al.*, 2002; Wadden *et al.*, 2012; Papandreo *et al.*, 2016).

Dietary Patterns (DPs)

As nutrients and foods are consumed in combination as part of a meal, evidence supports the use of dietary patterns, which are statistically derived to describe an individual's diet as a

whole, and are useful in accounting for the complex nature of food consumption as opposed to assessing nutrients (Newby and Tucker 2004). Moreover, DPs with high consumption of high-fat or sugary foods have also been found to be associated with obesity development in children (Emmett *et al.* 2015). A change in diets, including an increase in processed-foods with decreased consumption of fruits and vegetables, has been linked to the increase of childhood obesity (Frazao 1999; French *et al.* 2001). Dietary patterns are most commonly statistically found using either Principle component analysis (PCA), cluster analysis, or reduced rank regression (RRR) (Kant 2004; Newby & Tucker 2004). Studies that have investigated dietary patterns with obesity outcomes have generally been reported on adults and have shown conflicting results. Those investigating prospective studies on the diets of children are limited (Togo *et al.* 2001; Newby 2007). However there have been a number of publications using the Avon Longitudinal Study of Parents and Children (ALSPAC) cohort, a birth cohort from Bristol, England that began in the early 1990s, which have provided valuable insight on DPs (Emmett *et al.* 2015).

Evidence from an ALSPAC have investigated dietary patterns in 7-year-old children (n=8,286) to demonstrate the dietary intake of children in England and identified 3 dietary patterns: processed, traditional and healthy (Northstone & Emmet 2008; Smith *et al.* 2011; Cribb *et al.* 2012; Emmett *et al.* 2015). This study concluded that children who are introduced to either the ‘healthy’ or ‘processed’ DP by age 7 are likely to carry it into their adolescent years (Northstone *et al.* 2012).

Generally, those who consume a ‘processed’ dietary pattern, or one similar, consume greater refined-grains, processed-meats, pizza, chips, fizzy-drinks, and sweets, and are low consumers of unrefined-grains, poultry, fish, pulses, pasta, vegetables, fruit, and water. Cribb *et al.* (2012) investigated DPs among the ALSPAC cohort with nutrient composition reported linear

correlations, which provided evidence that this DP was positively associated with energy intake. After adjustment of energy, it was negatively associated with all nutrients, except for total sugars and saturated fat, indicating this DP was energy-dense and nutrient-poor.

Those children who are classified as having a more ‘traditional’ dietary pattern were found to be high consumers of poultry, red-meat, fish, potatoes, rice, and vegetables. They also tend to be low consumers of unrefined-grains, processed-meats, pizza, pulses, nuts, chips, sweets, and crisps. This DP was found to have a moderate association with EI, while protein, fibre, and micronutrient correlations indicated this DP was relatively nutrient-rich (Cribb *et al.* 2012).

Those with a ‘healthy’ DP consume greater unrefined-grains, fish, cheese, pulses, nuts, and less refined-grains, chips, SSBs, and sweets. This DP showed the weakest positive association with EI, and was negatively associated with fat intake, but showed strong positive correlations with protein, fibre, and most micronutrients, therefore describing this diet as also being nutrient-rich (Cribb *et al.* 2012). Northstone *et al.* (2012), using cluster analysis, expanded that those in the ‘healthy’ DP also tended to consume more than double the amount of fruit (122g/d) than those in the ‘processed’ (47g/d), also with more vegetables and less crisps consumed.

A review published by Emmett *et al.* (2015) investigated the varying ALSPAC based studies among 7-year-olds and showed that an RRR derived ‘energy-dense, low-fibre, high-fat’ DP was found to be associated with increased adiposity (Johnson *et al.* 2008; Ambrosini *et al.* 2012). This DP, similar to the PCA derived ‘processed’ DP, had no association with BMI categories. It did, however, produce a positive linear trend between the adjusted odds of excess adiposity ($p < 0.0001$), which was measured directly using DXA (Johnson *et al.* 2008; Ambrosini *et al.* 2012). Using PCA, Smith *et al.* (2014) investigated body weight between 9-11-year-olds and found a small negative association between a ‘healthy’ DP and fat mass.

Overall, better micronutrient profiles are associated with the ‘healthy’ and ‘traditional’ patterns, opposed to the ‘processed.’ Higher consumption of fruits, vegetables, and unrefined-grains were more so associated with the healthier DPs with better nutrient profiles. The less healthy, or ‘processed’, DPs tended to have higher consumption of refined-grains, crisps, and sweets (Cribb *et al.* 2012). All methods indicated that fruits, vegetables, and unrefined-grains impacted if an individual was consuming a healthy diet or not, and some of the findings suggested that children with greater adiposity were not consuming these diets (Emmett *et al.* 2015). Though indicating certain DPs are associated with excess adiposity among children, there is evidence from clinical trials also indicating only energy restriction, regardless of DP, is associated with better weight outcomes (Wadden *et al.* 2012).

Evidence has shown that children who are introduced to either the ‘healthy’ or ‘processed’ DP by age 7 are likely to carry it into their adolescent years (Northstone *et al.* 2012). Generally, those who consume a ‘processed’ DP, or one similar, consume greater refined-grains, processed-meats, pizza, chips, fizzy-drinks, and sweets, and are low consumers of unrefined-grains, poultry, fish, pulses, pasta, vegetables, fruit, and water. In addition Emmett *et al.* (2015) reported that among 7-year-olds a ‘energy-dense, low-fibre, high-fat’ dietary pattern was found to be associated with increased adiposity (Ambrosini *et al.*, 2012), suggesting that overall, better micronutrient profiles are associated with the ‘healthy’ and ‘traditional’ patterns, opposed to the ‘processed.’ Higher consumption of fruits, vegetables, and unrefined-grains were more so associated with the healthier DPs with better nutrient profiles. The less healthy, or ‘processed’, DPs tended to have higher consumption of refined-grains, crisps, and sweets (Cribb *et al.*, 2013). All methods indicated that fruits, vegetables, and unrefined-grains impacted if an individual was consuming a healthy diet or not, and some of the findings

suggested that children with greater adiposity were not consuming these diets (Emmett et al., 2012).

Association of Dietary factors including fruit and vegetable intake and development of obesity

Some studies have shown that children's dietary behaviours remain comparatively unchanging over time (Skinner et al., 2002) while others have suggested that the quality of diet deteriorates with age, especially with regards to fruit and vegetable intake (Lytle et al., 2000). Furthermore, it has been suggested that foods introduced after the age of four are more likely to be disliked and avoided which highlights the importance of early learning of the beneficial dietary behaviours (Cooke and Wardle, 2005). A systematic review of 60 primary research studies has found that parental modelling and dietary fruit and vegetable intake were both significantly positively associated with fruit and vegetable intake in children and young adults (Pearson, Biddle and Gorely, 2009). Other factors influencing children's fruit and vegetable intake included the accessibility and availability of fruit and vegetables, the existence of family rules requiring their intake, parental encouragement and the frequency of home-cooked meals. Interestingly, higher fruit and vegetable intake has been shown to be an indicator of higher-quality diets, rich in micronutrients and dietary fibre and diets with high content of fruits and vegetables are associated with lower risk of cardiovascular disease in young adults (Mellendick et al., 2018). This cardio protective effect of higher dietary intakes of fruits and vegetables in young adults was shown to be independent of factors such as gender, race or socioeconomic status and was demonstrated in studies from both developed and developing countries (Yang et al., 2018; Mellendick et al., 2018). Interestingly, consumption of other forms of fruits and

vegetables, such as dried or canned, was also demonstrated to positively correlate with higher dietary quality and with greater intakes of essential nutrients (Freedman and Fulgoni, 2016).

Consumption of fruit and vegetable juices in a cohort of French children and young adults showed that higher consumption was positively associated with increased intake of fruit and vegetables, compared to those not consuming fruit or vegetable juices (Francou et al., 2015). Furthermore, the consumption of fruit and vegetable juices was positively associated with higher-quality diets and with better compliance with healthy eating guidelines (Francou et al., 2015), suggesting that consumption of fruit and vegetable juices forms an important element of healthy dietary habits. However, in the UK recommendations suggest restricting consumption of fruit juices to help limit the intake of free sugars which has been associated with poorer diet quality and increased body weight and adiposity, and dental caries in children and young adults (Lee et al., 2015; Bleich and Vercammen, 2018; Hu, 2013; Francis et al., 2009) as consumption potentially displaces other essential nutrients (Crowe-White et al., 2016).

Sufficient intake of fruit and vegetables (F&V) has been related epidemiologically with reduced risk of many non-communicable diseases. Currently, much interest are focused on the vital role of antioxidants which impart bright colour to F&V and act as scavengers cleaning up free radicals before they cause detrimental health effects . Moreover, fibers found in F&V have been shown to reduce intestinal passage rates by forming a bulk, leading to a more gradual nutrient absorption (Pem et al., 2015) hence preventing constipation. They can be fermented in the colon, increasing the concentration of short chain fatty acids having anticarcinogenic properties (Pem et al., 2015) and maintaining gut health. Several studies have highlighted the CVD risk-reducing potential of F&V whereby their intake were strongly associated with lower

cardiovascular risk factors such as lower blood pressure (BP), cholesterol and triacylglycerol thus preventing premature cardiovascular disorders (Woodside et al., 2013). Recently Habauzit et al, reported that fruits containing a high amount of anthocyanins, flavonols and procyanidins, such as berries, grapes and pomegranate are effective at decreasing cardiovascular risk while citrus fruits and apples had a moderate effect on BP and blood lipid level. An increased consumption of carotenoid-rich F&V maintains the cholesterol level in blood since they reduce oxidative damage and cause an increase in LDL oxidation resistance (Habauzit et al, 2013). Moreover, Based on available evidence, a clear relationship between F&V and diseases has been well established (Pem et al., 2015). The accepted recommendation is to consume a variety of F&V because studies demonstrate that a combination of F&V have more potential benefits rather than a single fruit or vegetable (Woodside et al., 2013). However further studies are warranted.

Interestingly, phytochemicals in F&V have been found to act as anti-obesity agents because they may play a role in suppressing growth of adipose tissue (Pem et al., 2015). Adiposity is closely related to biomarkers of oxidative stress and inflammation and a diet rich in F&V can modify these adiposity related metabolic biomarkers in overweight women. A recent study by Vilaplana et al demonstrated that papaya and Morinda exhibited high lipase inhibition which can be considered as potential options for the management of obesity and maintaining body weight (Vilaplana et al., 2012). It is also understood that fruits and non-starchy vegetables are very low in energy since they contain high amount of water and fiber and can be consumed in a relatively larger amount contributing to increased satiety to maintain normal weight (Vilaplana et al., 2012). Hence an increased FVI can help to ease weight loss and this can be achieved when F&V displace high-energy-dense foods such as saturated fats, sugar so that the overall energy density of the diet is reduced (Pem et al., 2015). Additionally, fruits have been

suggested to prevent obesity since they add up to dietary variety both between and within food groups and palatability to the diet which has been revealed to be an important predictor of body fat. However discrepancies exist with respect to F&V with high glycemic index carbohydrates that are related to a more immediate decrease in appetite and increase in food intake in the short term (Jeewon et al., 2015). High consumption of fructose in F&V is related to obesity in rodents but no effect has yet been demonstrated in humans (Jeewon et al., 2015). FVI in overweight and obese people is much lower than the recommendation since they tend to restrict intake of these F&V when trying to lose weight. A significant relationship was observed between BMI and vegetable intake whereby overweight participants had lower intake of vegetables (Jeewon et al., 2015). This finding is consistent to that of Epuru et al who also found a clear trend between prevalence of obesity and low FVI (Epuru et al., 2011; Pem et al., 2015).

Contribution of snacks to development of obesity

Dietary habits such as snacking in excess, eating out, or skipping meals are reported to result in increased EI and lower nutritional status and increases the risk of becoming overweight or obese (Malik et al., 2009). Snacking has been found to increase EI, specifically among primary schoolchildren, with the majority of snacking coming from the consumption of desserts and sugar-sweetened beverages (SSBs), and it's been found that just one serving of SSBs had per day increases childhood obesity risk by 14% (Ludwig et al., 2001; Piernas & Popkin 2010; Evans et al., 2014). Consumption of SSBs, increased portion sizes, and eating meals away from home have all been positively associated with excess weight gain in children (Malik et al., 2009). The modern-westernized trend of increased portion sizes can have a dramatic impact on EI, and portion sizes are thought to increase along with consumption of high-fat meals, such as with fast food, due to having less of an effect on satiety (Kling et al. 2016).

Dietary guidelines have changed over time to reflect new scientific evidence and government recommendations to promote a healthy balanced diet. The Eat well guide was launched in 2016 by Public Health England as a pictorial guide to aid in communication of a healthy, balanced diet to reduce excessive consumption of foods high in free sugars, salt and saturated fats and increase consumption of foods with more dietary fibre. (Eat well guide BNF, 2016).

Association of Carbohydrate and sugars in development of obesity

In the UK, grain and cereal products contribute up to 37% of total energy intake in 4 -18year olds (PHE, 2018), therefore provides the majority of energy in diets. Excessive carbohydrate intake therefore has the potential to contribute to surplus energy intake and studies have investigated its association with the development of obesity. The effects of different carbohydrates are related to the type of carbohydrate, their rate of digestibility and their physical function in the gastrointestinal tract (Brown et al., 2010). Evidence suggests that high glycaemic index (GI) carbohydrates are associated with increased adiposity, whereas high fibre, low glycaemic index carbohydrates may be protective (Gibson et al., 2006). Excessive free sugar (FS), inadequate dietary fibre (DF), high glycaemic index (GI) and glycaemic load (GL) diets, are all recognised as potential risk factors. The strongest evidence to date exists for carbohydrates rich in FSs, particularly sugar- sweetened beverages (SSBs) and subsequently, has influenced policy.

Free sugars

The role of free sugars (FS) as a contributory factor in childhood obesity has been the focus of recent public health strategies. FSs are defined as sugars added to foods and beverages by cooks, consumers or manufacturers (SACN, 2015). Public health efforts have focused on reducing FS consumption in accordance with strategies including the Soft Drinks Sugar Levy introduced by UK government bodies (Elliott-Green et al., 2016). Evidence indicates that FSs

currently provide 13% of a child's total energy intake, meaning that children are consuming more than double the recommended amount (PHE, 2016). In keeping with these concerns, robust evidence supports a substantial reduction in free sugar consumption to decrease childhood obesity risk.

Evidence from a meta-analysis concluded that children with the highest intakes of FSs had a significantly increased risk of being overweight/obese compared to those with the lowest intakes (Te-Morenga et al., 2013). This was similar to findings of Ambrosini et al. (2016) who reported a significant positive association between FS intake and adiposity in children. This evidence is mirrored in a systematic review for the Scientific Advisory Committee on Nutrition (SACN). This review concluded that FSs have an influence in childhood obesity owing to the 1275 KJ surplus of energy intake that typically coincides with diets high in FSs. The significant positive correlation between the two parameters was also confirmed by Maunder et al. (2015) who hypothesized that the link is mediated by the micronutrient dilution often observed in high FS diets.

Sugar sweetened beverages (SSBs) have been identified as the primary source of FSs in the diets of children (Bailey et al., 2018). Evidence from a randomised controlled trial (RCT) revealed that children consuming 250ml/day of SSBs for 18 months had a greater increase in weight (7.37 kg) compared to those consuming sugar-free beverages (6.35 kg) (De-Ruyter et al., 2012). In an updated analysis, Katan et al. (2016) once again identified a strong correlation between the two parameters. In fact, results were even more significant than findings of the original study by De-Ruyter et al. (2012). Children who consumed 250ml/day of SSBs had a greater increase in body weight of 8.67kg. It should be considered that all children assessed were overweight, possibly indicating that the association between SSBs and weight becomes more significant as children get heavier. Similar evidence from a longitudinal cohort reported

a dose-response relationship noting a significant increase of 0.24kg/m^2 in the BMI of children consuming ≥ 2 servings/day of SSBs over one year (Berkey et al., 2014).

Additionally, findings from cross-sectional studies have reported significant positive correlations between SSB consumption and sum of skinfolds (Dror, 2014). Similarly, data from the National Diet and Nutrition Survey reported that consumption of $\geq 250\text{ml/day}$ of SSBs amongst American children was associated with a significant increase in waist circumference and body fat (Bremer et al., 2019). These significant findings are well-replicated across several countries including Canada, Spain and Britain whereby children who consumed a similar amount of SSBs had a 47% increased obesity risk compared to those who consumed less (Grimes et al., 2013).

Interestingly, findings from a review of intervention trials investigating the relationship between FS consumption and childhood obesity reported null associations. It is possible that these findings may be owing to poor compliance observed in three of the five included trials (Te-Morenga et al., 2013). Nevertheless, extensive research suggests that FSs, particularly from SSBs, have significant contributions to childhood obesity. Whilst the strength of the association varies between studies, robust evidence is in keeping with the recommendation to restrict FS consumption to 5% of total energy intake to prevent this epidemic worsening (SACN, 2015).

Other studies have investigated the combined effect of FS and dietary fibre (DF) intake with childhood obesity. Okubo et al., (2015) revealed that the likelihood of a child being overweight or obese was increased by 52% if their diets were high in FSs and low in DF. Therefore, DF must also be recognised as a potential causal factor in childhood obesity.

Dietary fibre

Low intakes of dietary fibre (DF) have been identified as influential in the development of childhood obesity (Edwards et al. 2015). DF has been defined as “edible carbohydrate polymers with >2 and up to 9 monomeric units that are not digested in the human small intestine” (EFSA, 2010, pp.11). There are many plausible mechanisms as to how DF can influence body weight. Hammadi et al. (2017) suggested that the increased chewing required in fibre-rich foods triggers satiety signals, delays gastric emptying and subsequently regulates appetite. High DF consumption (25g/day) also typically coincides with favourable dietary patterns characterised by low fat and high micronutrient intake which confers protective effects against weight gain (Menni et al., 2017).

The inverse association between dietary fibre and weight has been well established in adults. In a systematic review of RCTs, Thompson et al. (2017) reported that those with low intakes of DF (6.3g/day) were 26% more likely to be overweight/obese compared to those with higher intakes (27g/day). Similarly, a prospective cohort of European adults discovered a significant inverse association between DF, waist circumference and body weight (Du et al., 2010). These findings support a beneficial role for DF and are reflective of the recommendation to increase the Dietary Reference Value of fibre to 30g/day for adults (SACN, 2015).

Whilst the association is well recognised in adults, evidence is scarce for children and the relationship between DF and body weight is less-well established. A limited number of observational studies suggest that fibre intake is not associated with childhood obesity (Davis et al., 2007; Kring et al. 2008; Cheng et al., 2009). It is noteworthy that these studies were predominantly confined to Western countries where diets are characteristically very low in fibre and energy dense (Breen et al., 2014). It should also be considered that studies reporting no association have small sample sizes and dietary intakes may be subject to recall bias.

Conversely, a systematic review examining data from the large UK birth cohort ‘ALSPAC’, revealed that inadequate DF intake was associated with an increased childhood obesity risk (Ambrosini et al., 2014). A study investigating Latino children also reported a significant inverse relationship between low intakes of soluble fibre and central adiposity (Davis et al., 2009). Likewise, Raynor et al. (2011) also supports the premise that inadequate DF intake leads to weight gain. Results concluded that children who consumed <7g/day of DF had significantly higher percentage energy intakes from fat and saturated fatty acids compared to those consuming more than double the amount of fibre (18g/day).

Furthermore, evidence suggested that high DF consumption decreases childhood obesity risk. Findings from an RCT conducted by Hume et al. (2017) concluded that 8g/day of fibre supplementation in children reduced BMI z-scores by 3.4%. Likewise, evidence from the ‘CHANGE’ intervention study reported that children with higher intakes of wholegrain (>1.5 servings/day) had a 40% decreased obesity risk compared to those with lower intakes (<1.0 servings/day) owing to the DF content of the grains (Choumenkovitch et al., 2013). These studies indicate that low intakes of DF increase childhood obesity risk and similarly, diets high in fibre decrease the risk. Collectively, recent findings justify the recommendation for children aged 5-11 years to consume 20g/day of DF (SACN, 2015).

Nonetheless, recent findings are inconsistent with those of earlier studies and evidence surrounding glycaemic indices and childhood obesity is also inconsistent.

Importance of healthy eating to prevent obesity

Healthy eating is particularly vital for children and young adults, as not only does it affect intellectual and cognitive development, but it also engenders habits and behaviours that have increasingly greater risk as the individual ages; cardiovascular disease for example can take

decades to develop and is pre-disposed to by a lifetime of risk factor indulgence (Lobstein et al., 2004). Dietary habits can also have immediate short- and middle-term consequences on health, such as occurs when genetically-predisposed individuals develop coeliac disease due to modified and abundant gluten in modern processed western diets (Gujral et al., 2012).

Given the interest and public health relevance of eating behaviours, many people have sought to determine the factor that influence weight status and eating behaviours in young adults, as the transition to adulthood (when an individual has a good level of academic and life understanding) has been identified as a critical time for correcting deleterious behaviours (Lobstein et al., 2004). This can be of particular relevance to young adults leaving home for university or employment, where time constraints, new commitments and new experiences are forthcoming (Lobstein et al., 2004). Since living away from home is a vulnerable time in a young life, and a major contributing factor to weight gain, strategies for promoting healthy lifestyle behaviours in this population are vital.

Nutrition education approaches to prevent obesity

A variety of nutrition interventions which target obesity have been reported. However there is limited evidence as to the most successful approach. Such programmes have included educational programmes for children, young adults and also their parents to change dietary habits. The modes of distributing such knowledge also need consideration, to ensure that the message is spread using a medium or a method that effectively reaches the target population, be it the children and young adults or their parents. Thus, understanding of the level of awareness of what constitutes the healthy diet and of the barriers and facilitators to implementation of such diet in any particular population or culture are necessary for developing successful educational approach to tackling overweight and obesity among today's young

adults. Social networks is an effective tool which is explored further as a method of communication education messages.

Social networks in delivering health education

Social media offers a new group of tools whose efficacy as an intervention for lifestyle modifications is just beginning to be evaluated. The difference between social media and social networks is that, Social media can be defined as a group of online applications that allow for the creation of user-generated content, and which can be divided into five different types: (1) collaborative projects (e.g., Wikipedia), (2) blogs or microblogs (e.g., Word press), (3) content communities (e.g., YouTube), (4) social networking sites (e.g., *Facebook and E-mail*) and (5) virtual gaming or social worlds (e.g., *Second Life*) (Ainsworth et al., 2015). However, the term Social media normally used for channels that provide information from one side provider e.g. (TV, newspapers). Hence, Social media is a comprehensive concept and definition of social networking sites (SNS) which are generally defined as web-based platforms that allow individuals to create their own personal profile, share information (two sides providers of information) and build a network of connections with other users (Ainsworth et al., 2015).

One potential strategy to curtail these deleterious cycles is to conduct public and private (e.g. school and workplace-led) obesity prevention interventions, which could be delivered using technologies such as online social networks sites that have popularity and utility amongst young adults (Kind and Evans, 2015). Social networking sites (SNS)—such as email, Facebook, and Twitter—have been used extensively in public health and prevention interventions to change behaviour and improve health outcomes (Ainsworth et al., 2015). Several aspects of SNS—including social support, empowerment, peer pressure, and interactive information-emotion sharing—have the potential to influence patients' health behaviours and increase adherence to and engagement with such interventions (Ainsworth et

al., 2015). Yet little is known about the actual effect of SNS on behaviour change and on the factors that may influence user interaction and experience, such as usability, user satisfaction, and level of technology acceptance or engagement. Therefore, there is a need to understand the effectiveness of SNS in the context of wider health promotion methods and evidence not simply assuming that interventions can be ported from one medium to another.

Previous reviews of the literature have provided mixed results about the effectiveness of SNS for health promotion with many authors characterizing the effect of online social networking on behaviour change as positive, but not statistically significant (Ainsworth et al., 2015). For example, (Karda and Itani, 2013) identified both positive and less successful examples of the application of social networks (including blogs) for health promotion. However, the authors also concluded that there is a need for precise evaluation metrics and for behaviour change interventions to be grounded in theory in order to successfully measure and assess their effectiveness. The previous work in this area suggests that the lack of clear evidence can be attributed to the following factors.

In parallel to general purpose of SNSs, health-specific SNSs are also emerging (Laranjo et al, 2014). Some are oriented towards patients with a specific chronic condition (e.g., Diabetes), others are more general and open to patients with any chronic condition (e.g., PatientsLikeMe), and a few others target people wanting to change a particular health-risk behaviour (e.g., smoking cessation) or other health-related lifestyle factors (Laranjo et al, 2014). The application of SNSs in the health domain shows tremendous potential. At the population level, they are currently being used for public health surveillance, both for communicable, and non-communicable diseases. At the individual level, they are able to facilitate access to health-related information and social support, promoting better-informed treatment decisions (Laranjo et al, 2014). Given that lifestyle behaviours are nowadays responsible for the global burden of

non-communicable diseases, increasing attention is being given to using SNSs to fight this trend (Laranjo et al, 2014). Interestingly, studies of offline social networks have demonstrated the actual role of social influence in spreading certain risk behaviours, such alcohol consumption, smoking, and obesity (Laranjo et al, 2014). Researchers are now focusing on how to leverage social influence to promote healthy behaviours. The fact that SNSs are widely accessible across geographical barriers, and that they are increasingly being used by people on a daily basis, turn them into especially interesting loci for public health interventions in the behavioural domain (Laranjo et al, 2014).

Indeed, a survey conducted recently in the USA showed that young adults aged between 18-29 revealed that 89% of this group use social networks on a daily basis, with 87% using their smartphone to access the internet. Thirty-two percent of participants also admitted to reading and posting to blogs, demonstrating the high levels of engagement that can be generated with young people via such approaches (Patrick et al., 2014). Of these modern technologies that stand poised to impact health, online social networking/media is the most broadly used, and its popularity (and choice of platforms) is expanding rapidly.

The popularity and utility of online social media websites has been largely attributed to Facebook and Twitter, with the former counting with more than 2 billion users in July 2018 (Patrick et al., 2014). Such platforms could and should be used to share important values regarding health, food and well-being. Current estimates of user usage of such sites suggest the efforts would be worthwhile. For example, a study of several hundred college students in North America indicated that students spend approximately half an hour per day on Facebook (Patrick et al., 2014), which is likely to be an under-estimate when use of messenger and photo-blogging applications (such as Instagram and WhatsApp – both owned by Facebook) are also considered.

Additionally, it was elegantly indicated by research that SNS (e.g. Facebook) can significantly contribute to modifying social habits associated to weight gain and obesity-related behaviours, such as the satisfaction regarding being obese, consuming unhealthy foods, and sedentary life); social network contagion has emerged as a well-established concept that might significantly influence weight control among young adults (Kramer et al., 2014; Napolitano et al., 2013), some studies have examined the influence of social network on chances of becoming obese (Kramer et al., 2014; Napolitano et al., 2013) and whether obesity could spread within a social network, like a “contagion” (Kramer et al., 2014; Napolitano et al., 2013). However, it is difficult to distinguish social network effects from environmental confounds such as the clustering of obesity-related behaviours within friendship networks (Napolitano et al., 2013).

The role of social networks in modulating behaviours in young adults

The role of wider social networks, including the family and peers, in affecting and modulating dietary behaviours is often cited as essential in effecting positive behavioural change, such as the adoption and maintaining of healthy dietary habits. Numerous studies show that social support from friends, colleagues, family and professionals is often cited by young adults as necessary to achieve a positive effect in terms of dietary behaviours and lifestyle (Biggs et al., 2014; Sampat et al., 2014). These observations point to the need to target the social environment of young adults when considering weight management and healthy lifestyle interventions for those age groups, although the specific mechanisms underlying the role of peers within the social network of young adults require further research and understanding (Salvy et al., 2012).

Parental dietary behaviours and their intake of healthy and unhealthy foods during main meals and while snacking have been shown to correlate with consumption of whole fruits and vegetables and fruit juices by young adults and this influence is passed on through

encouragement, role modelling and availability of healthy food (Pearson, Biddle and Gorely, 2009; Blaine et al., 2017). Furthermore, parental socioeconomic status and their education have been shown to be associated with adolescents' dietary habits as well, pointing to the importance of interventions targeting the parents and the family environment to achieve positive change in adolescents' behaviours (Yee, Lwin and Ho, 2017). On the other hand, those socioeconomic correlates can help to identify the families who might need educational and other support to help promote healthy diet among young adults. Furthermore, research shows that a combination of different parental and familial approaches might be necessary to achieve dietary goals in young adults, including encouragement, praise and guidance or rule-making and restrictive parenting, the effectiveness of which depends of the child's age and the situation (Yee, Lwin and Ho, 2017).

Delivering dietary advice that is easy to understand and remember is also important, as young people are often overwhelmed with the amount of information available in the family and school environment or online profile (Yang et al., 2018), some conflicting and confusing. Developing simple messages is therefore vital to achieving the desired changes in dietary habits. A notable example of such a simple message developed in the study of dietary intake of fruits and vegetables among a large, 18,757-strong, cohort of Chinese young adults (13 to 17 years old) is the advice to consume the equivalent of at least three fists of vegetables to meet the recommended daily portion for the young adults and thus, to help improve individuals' blood pressure profile (Yang et al., 2018). Furthermore, when considering the options of targeting young adults through their interactions via online social networks, it has to be noted that there is high prevalence of screen time among young adults and that the screen-time and unhealthy eating behaviours are correlated and often coupled (Pearson et al., 2017). In particular, screen-time (both while television watching and using online social media) are

correlated with consumption of energy-dense foods and the development of other habitual unhealthy dietary behaviours (Pearson et al., 2017). Those behaviours might require targeted strategies, combining “nudging” and conscious encouragement with the social, individual and family support to effectively overcome the unhealthy habitual dietary patterns.

It is vital that the problem of childhood and adolescent overweight and obesity is considered comprehensively, in all its complexity. Overweight and obesity are the results of numerous factors, including suboptimal dietary habits and the lifestyle and social aspects, which need to be thoroughly explored and understood, so that any interventions target those influencers effectively. It is likely that any single intervention will not be successful in addressing the epidemic or halting its progress, and that multilevel interventions that target those various factors from different angles will be needed. Such programmes might include either dietary supplementation in schools, university or educational programmes for children and young adults and also their parents, and for the prospective parents to help them develop optimal dietary habits and implement those when bringing up their children. The modes of distributing such knowledge also need consideration, to ensure that the message is spread using a medium or a method that effectively reaches the target population, be it the children and young adults or their parents. Thus, understanding of the level of awareness of what constitutes the healthy diet and of the barriers and facilitators to implementation of such diet in any particular population or culture are necessary for developing successful approach to tackling overweight and obesity among today’s young adults.

The overall aim of this thesis is to investigate the nutritional and lifestyle factors associated with dietary habits of two stages of the lifecycle (children and young adults) required to prevent obesity

This aim has been addressed through the use of data collected from two different cohorts: data collected from children (aged 6 years) who were participants in HAPO Family study and participants recruited from Ulster University to take part in a RCT providing fruit and vegetables to students to influence behaviour.

This aim was addressed through the following chapters:

- 1) Interventions using social networks for obesity prevention among university students: a systematic review (**Chapter 2**).

Aim of this chapter: to systematically evaluate the use of social network interventions used to prevent obesity among university students.

- 2) To explore the eating behaviours and experiences of young adults (university students) and identify appropriate methods for delivering nutrition education messages (**Chapter 3**).

Aim of this chapter: to explore the eating behaviours and experiences of students attending university in Northern Ireland while living away from home.

- 3) To plan and deliver a RCT using 'Facebook' to increase fruit and vegetable consumption in young adults (university students) and investigate the impact of this as a method of providing nutritional education (**chapter 4**).

Aim of this chapter: to deliver and evaluate a nutrition intervention aimed at increasing FV intakes of university students living away from home.

- 4) To identify dietary patterns using PCA and investigate the relationship with obesity in young children using data from the HAPO Study (**Chapter 5**)

Aim of this chapter: to identify dietary patterns in diets of children using PCA method and to investigate the relationship between dietary patterns identified and children's anthropometry/BMI Z scores

- 5) To explore the relationship between dietary intakes, in particular carbohydrate foods and body mass index and in addition explore the main sources of sugars consumed and contribution to energy intakes from HAPO study (**chapter 6**)

Aim of this chapter: to investigate if dietary intake differs according to BMI category in particular carbohydrate foods and body mass index in children. Secondly, the major sources of sugars and their contribution to energy intake in the diets of children will be identified.

- 6) Discussion (**Chapter 7**)

Aim of this chapter: to discuss and interpret the overall implications of nutritional and lifestyle factors associated with dietary habits of children and young adults using and to identify future work in the field healthy eating habits and of obesity

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Chapter 2

Interventions using social networks for obesity prevention among university students: a systematic review

Abstract

Background

The rising prevalence of global obesity and lack of successful prevention strategies require novel, effective methods to reduce the obesity epidemic. Popularity of social network sites are increasing and effectively attract billions of people globally on a daily basis, are being explored as new-age tools to combat the epidemic. Students are traditionally considered a challenging group to engage in health-promotion and obesity prevention strategies. Social networks, popular among young adults, represent an opportunity to influence health-related behaviour.

Objectives

The aim was to systematically evaluate the use of SNS in weight loss interventions among university students.

Methods

8 electronic databases were searched from January 2000 to January 2017. The search strategy adopted was developed using a PICOS criteria (Population, Setting, Intervention, Comparison Outcome). Inclusion criteria were: (1) only articles fully published in English, (2) studies included the use of some form of SNS, (3) studies conducted on young adults aged 18-35 years old, (4) participants included both males and females, and apparently healthy university students, (5) only studies were designed as randomised controlled trials. All assessed social network interventions delivered within an educational setting, with 3 reporting benefits when multicomponent.

Results

Searches identified 400 references, of these 6 studies (2125 university students) met the inclusion criteria. E-mail was the most utilized type of social network. 2 out the 6 studies reviewed showed significant BMI reduction and alteration of behaviour in the intervention group as compared to the control group. The majority (n=4) reported no behaviour modification effect.

Conclusions

This systematic review suggests that multicomponent interventions which include social networks might be useful in assisting university students to lose weight.

Introduction

Social media offers a new group of tools whose efficacy as an intervention for lifestyle modifications is just beginning to be evaluated. Social media can be defined as a group of online applications that allow for the creation of user-generated content, and which can be divided into five different types: (1) collaborative projects (e.g., Wikipedia), (2) blogs or microblogs (e.g., Word press), (3) content communities (e.g., YouTube), (4) social networking sites (e.g., *Facebook and E-mail*) and (5) virtual gaming or social worlds (e.g., Second Life). However, the term Social media normally used for channels that provide information from one side provider e.g. (TV, newspapers). Hence, social media is a comprehensive concept and definition of social networking sites (SNS) which are generally defined as web-based platforms that allow individuals to create their own personal profile, share information (two sides providers of information) and build a network of connections with other users. Also e-mail is considered as a SNS because if Facebook site is a private community of friends is considered as a social network, then so is email. They both have the same requirements 1) profiles (emails have signatures), 2) ability to connect to each other (the act of emailing, and often responding, 3) do something useful (email users share information, and sometimes collaborate) (Lim et al, 2018).

SNS, such as *Twitter, Facebook and Email*, have quickly risen to become part of everyday life around the world. These sites have attracted billions of users from around the world. Recent statistics show that as of September 2013, 73% of the adults aged over 18 were found to be using some form of SNS (Laranjo et al., 2014). The most widespread platform among these SNS is *Facebook* with over 1.71 billion active users each month around the world (September 2016), followed by *WhatsApp* with approximately 1 billion monthly active users (January 2018). To evaluate the use of SNS as an intervention method, research has focused on the

impact of health-related behaviour among young adults that can be attributed to such SNS interventions (Korda and Itani, 2013). Alongside *Facebook* and *Twitter*, health-specific SNS have also been evolving (Korda and Itani, 2013). Some studies suggest that SNS can be ideal tools for identifying and communicating any required health behaviour changes for obesity prevention. While there have been a number of studies examining the use of SNS-based interventions for promoting health-related behavioural change, the field remains relatively novel and thus the evidence proving its effectiveness is still in the initial stages (Marks et al., 2006; LaChausse, 2012; Robroek et al., 2012; Ezendam et al., 2012). Researchers have suggested several benefits of using SNS for promoting such behaviour change. For example, due to the existence of high levels of user interaction, SNS provide a cost-effective means of potentially improving quality-of-life by enabling peer-to-peer communication, that allows provision of mutual healthcare support and advice (Moorhead et al., 2013). According to the World Health Organization (WHO), over 1.4 billion adults are overweight and an additional 500 million are obese globally (WHO, 2014). Both conditions increase cardiovascular disease and diabetes risk, which are the leading causes of mortality, together taking over 15 million lives every year. Despite the well-established negative health-effects of obesity, numbers of obese individuals seeking some form of medical intervention increases. With the rise of the technology era, researchers are exploring the use of new technology tools, which can help physicians track and manage patients remotely (Bahr et al, 2009). Several researchers who have sought to manipulate social networks by focussing on connected individuals, found that such interventions showed statistically significant reduction of BMI and overall improvement of health. However, existing research reveal very little about specific processes by which SNS obesity interventions may be effective. A systematic review by Paul-Ebhohimhen et al. (2009) which examined the effectiveness of individual-based to group-based treatment modes by SNS for managing obesity in adults, found that in group settings weight loss interventions delivered

by social networks was more effective, even though the review did not mention the way through which the result can be accomplished. Many new students appear to find adapting and maintaining a healthy lifestyle difficult during the transition to university-life (Napolitano et al., 2013). Dietary behaviours in young adulthood may have major long-term health implications lasting well into adulthood (Strong et al., 2008). Hence, as living away from home is a vulnerable time in young adulthood and a major potential contributor to unhealthy dietary intake and weight gain, strategies for promoting healthy lifestyle behaviours in this specific population are essential. Although the precise methods in which SNS contribute to obesity management are continue to be debated, several RCTs have evaluated the use of SNS in combating this issue. The aim of the present review was to systematically evaluate evidence in published literature related to the effectiveness of different SNS based strategies in weight loss intervention among university students.

Study protocol

The present systematic review was conducted based on the guidelines of Cochrane Collaboration methods (Higgins. 2013).

Search strategy

The search strategy adopted was developed using a PICOS criteria (Population, Setting, Intervention, Comparison Outcome) (Table 1) (Higgins. 2013). The decision to limit the start of the search date to 2000 was taken as it reflected that the focus of this systematic review is on top 15 SNS launched in year 2000 (determined as the most popular social networks worldwide as of January 2018). Only those written in the English language with randomised controlled trials (RCTs) conducted with human participants were included. The search was decided based on several search terms regarding SNSs, nutrition, and obesity prevention. The following terms were used: ‘social network’ or ‘Facebook’ or ‘Twitter’, or ‘Instagram’ and ‘diet’ or ‘nutrition’ or ‘weight with index’ and ‘MeSH’, while subheadings included ‘weight/obesity prevention’ or ‘loss’. The search term ‘food’ was followed by subheadings such as ‘intake’ was accompanied by subheadings such as ‘habits’ and ‘students’ and ‘university’ or ‘college’ (see Electronic Supplementary Material, (appendix 2) for full details of the search criteria).

Inclusion and exclusion criteria

Studies were included in this review if all of the following criteria were fulfilled: (1) only articles fully published in English between January 2000 to January 2017, (2) studies reported the use of any form of SNS, (3) studies conducted on young adults aged 18-35 years old, (note: young adulthood commonly known as a period when a person aged 18– 35 years, and due to that the aim of the SR was to target young adults as university students and excluded some cases of students who are aged above or below that range), (4) participants included both males and females and apparently healthy university students, (5) only studies were designed quantitative and randomised controlled trials (RCTs) because RCTs provide the strongest evidence on the effectiveness of interventions,(Akobeng. 2005), (6) types of intervention conducted during the academic year included e.g. textual information or videos through SNS alone or in combination with complex interventions based on Kaplan and Haenlein (2010) classification with an aim to prevent obesity. Published and unpublished studies were included in recognition that SNS are rapidly evolving platforms. All resources (full articles, books, dissertation and theses and hand searching) were used. The primary outcome measures interpreted as evidencing effectiveness of SNS included obesity prevention in terms of achieving healthy diet or healthy body weight or reduction in BMI. The most useable SNS among university students was a secondary finding, evidencing the popularity and prevalence of SNS use among university students. Studies were excluded if the intervention group was exposed to any intervention based on social media (non-SNS types) which constitutes a group of online applications that allow for the creation of user-generated content (e.g. television channel, *YouTube*) or focused on behaviours unrelated to the primary outcomes (e.g. changes in physical activity behaviour). In addition, interventions that were targeted intervention group with part-time students (because the present systematic review was conducted as to gain information to develop an RCT interests in full-time university students) , staff, those not

registered as university students, or a diagnosed medical condition, such as diabetes mellitus were also excluded.

Identification and data extraction of studies

Study identification was undertaken through searching databases by a single reviewer (AH). Titles and abstracts were screened using endnote software and duplicates and those not meeting criteria were removed. Full texts of remaining articles were obtained and assessed for eligibility against the inclusion criteria for all included studies. Two researchers (AH, AJH) identified and independently reviewed the remaining full text articles according to the pre-determined inclusion and exclusion criteria. Where a consensus could not be reached, a third member (AMG) of the research team was consulted and any inconsistencies between the researchers were resolved through discussion and agreement.

Data extraction was completed by a single reviewer (AH) using the Cochrane Collaboration data extraction tool in Microsoft Word 2014 (Microsoft, Redmond, Washington, USA) and verified by a second reviewer (AJH) (Higgins, 2013). (Appendix 2) Extracted data involved study characteristics, (combined (e.g. a study with many group arms and using different SNS) versus simple (includes a study describing only one SNS), and intervention description), population characteristics (target population, age and sex, and setting), outcome measures (primary and secondary), final results and conclusions.

Study quality and risk of bias

The Cochrane Collaboration Risk of Bias Tool was employed to assess the quality of included studies arrived at through search. Allocation concealment, incomplete outcome data, sequence generation, blinding, selective outcome reporting and other sources of bias were assessed. The risk of bias was carried out independently in duplicate by two researchers (AH, AJH), and variances between reviewers were resolved through consulting and consensus with a third member of the research team (AMG) using Cochrane Collaboration Criteria

Results

Study selection

Figure 2.1 shows the procedure adopted to select relevant studies. Searches identified 400 references which were screened by abstract for eligibility. Of these, 387 articles were removed as they did not meet the inclusion criteria. Reasons for exclusion included study design (not an RCT), population group (study not conducted in ‘young adults’ or ‘university students’), duplicate and year of publication which did not meet inclusion criteria. 13 full-text articles were retrieved and assessed for eligibility. Consequently, eight more articles did not meet eligibility criteria and were excluded after full texts had been reviewed. In total, 6 studies were considered valid for this review (Dadkhah, 2013; Gow et al., 2010; Hansen, 2013; Kattelman et al., 2014; Kothe and Mullan, 2014; Napolitano et al., 2013; Seely, 2013).

Characteristics of included studies and outcome measures

The 6 included studies represented a total of 2125 university students with 30% males / 70% females ranged in age from 18 to 26 years old with a BMI of participants across these studies ranging from 17 to 41kg/m² (Table 2.2). Only two countries were involved in the research reviewed in this study; one study was based in Australia (Kattelman et al. 2014) while the

remaining five were from the USA (Dadkhah, 2013; Gow et al., 2010; Hansen, 2013; Napolitano et al., 2013; Seely, 2013). The primary outcome measure was weight loss, observed in terms of either change in BMI or reduction of body weight (Dadkhah, 2013; Gow et al., 2010; Hansen, 2013; Kattelman et al., 2014; Napolitano et al., 2013). Recruitment strategies were diverse and included different approaches such as advertising with flyers, classroom announcements and university media, and mass-online emails.

Effectiveness of the social networks

Several studies (n=2) indicated that there was a positive outcome on weight loss when the SNS was combined with other forms of intervention (e.g. text messaging, on-line feedback), however, when using SNS alone (without other components) the SNS intervention was not successful in achieving weight loss (Napolitano et al., 2013; Gow et al. 2010). The other studies (n=4) were unsuccessful at modifying behaviour and achieving weight loss and concluded that SNS intervention was ineffective and recommended further research (Dadkhah, 2013; Hansen, 2013; Kattelman et al., 2014; Seely, 2013). Two studies reported mixed findings, Napolitano et al. (2013) stated that there was a significant weight reduction in the Facebook Plus group comparative to control group over time but not the Facebook only group relative to control and Seely (2013) found no significant difference in weight loss between groups while overall mean weight loss was greater in the intervention group than controls (see Table 2.2).

Types and uses of social networks

Across the 6 included studies, interventions typically included administration of online learning modules and self-report diaries using SNS with the primary outcome of weight loss and the secondary outcomes of improved diet (Dadkhah, 2013; Gow et al., 2010; Hansen, 2013;

Kattelman et al., 2014; Napolitano et al., 2013; Seely, 2013). FB was the most utilized type of social network (n=3), either isolated or as part of a combined intervention with other components (Dadkhah, 2013; Napolitano et al., 2013; Seely, 2013). Two of the selected studies for this review used email either exclusively or as an alternative form of intervention in combination with others (Gow et al., 2010; Kattelman et al., 2014). While a further three used Facebook as the exclusive intervention (Dadkhah, 2013; Napolitano et al., 2013; Seely, 2013), only one utilised Blackboard (Hansen, 2013). The duration of the study interventions ranged from 15 days to 3 months, while the follow-up period after the end of the intervention ranged from 8 weeks to 12 months. Only 2 studies did not report the follow up period (Hansen, 2013; Seely, 2013). The studies which used short term duration intervention (e.g. 4-6 weeks) showed positive and effective outcome (Gow et al., 2010; Napolitano et al., 2013) while other studies that used long term intervention reported ineffective outcome. However, regardless of the duration, or effectiveness, of the intervention no differences in outcomes were reported during the follow up period for any of the studies.

Quality of included studies

None of the studies were excluded on the basis of quality assessment. All studies were rated as low, unclear or at high risk of bias (Table 2.3).

Low risk of bias

Selection bias was low in five of the included studies (Table 2.3), demonstrating that random sequence generation was adequately described within the studies performed. Similarly, selective outcome reporting bias was low in four of the included studies (Table 2.3) which indicates that these studies reporting all expected results.

High risk of bias

Blinding of participants and personnel was classed as high risk of bias in four of the included studies (Table 2.3) since these studies failed to adequately report if they were blinded to group allocation. However, this is perhaps not unreasonable given the nature of social networks intervention which cannot be blinded. Similarly, four included studies (Table 2.3) scored highly for incomplete outcome data and five included studies were also identified as having other risks of bias, largely due to high attrition rates being unaccounted for, baseline imbalances and analysis of individual participants despite group randomisation leading to potential bias.

Unclear risk of bias

Performance bias was classed unclear for two included studies (Table 2.3) since these studies lack clarity on blinding of outcome assessors to study measures and failed to adequately report whether participants or study personnel were blinded to group allocation.

Discussion

This systematic review evaluated the evidence regarding the use and effectiveness of social networks sites in weight loss interventions among university students. The evidence presented in this review showed that Facebook was the most commonly used form of social networks as a tool to promote weight loss (Napolitano et al., 2013; Seely, 2013; Dadkhah, 2013) and was often combined with other interventions that employ other techniques such as online self-report, and peer-support. This review resulted in mixed findings about the usefulness of interventions based on social networks in achieving obesity management and improved behaviours among university students. Only two out the six studies reviewed showed significant BMI reduction and behaviour alteration in the intervention group using a combined approach as compared to the control group (Napolitano et al., 2013; Kattelman et al., 2014). There was significant heterogeneity between studies indicating that methodological differences are likely to have contributed to inconsistent findings. There was considerable variation in population, length of follow-up period (8 weeks to 12 months) and intervention given (e.g. type, exposure and frequency). Potential bias was apparent across the included studies which compromises the overall quality of these trials. Although all studies included were defined as randomised controlled trials, details of the randomisation method and/or allocation concealment were often clear but insufficient. Limited details of randomisation method may not suggest that the study randomisation protocol was unclear. Few studies mention blinding and only two studies reported blinding outcome for assessors and personnel (Napolitano et al., 2013; Gow et al., 2010;). Although a high risk of bias was unlikely to be introduced by lack of blinding, there is a possibility for bias introduced that could be avoided in future. Furthermore, there were high dropout rates in some studies (Seely, 2013; Kattelman et al., 2014). While only one study with low attrition rate reported using intention-to-treat (ITT)

analysis (Gow et al., 2010), it is recommended that ITT analyses technique must be carried out in all studies as this is considered to decrease bias produced by subsequent loss of participants at follow-up period which is the period after the end of the intervention. Significant changes in weight were reported in two interventions that incorporated SNS when compared to control group (Napolitano et al., 2013; Gow et al., 2010), suggesting that these interventions may be feasible and effective for enabling students to adopt healthy eating habits and prevent obesity only when the SNS intervention used in conjunction with another supported component. However, it is not clear why these specific interventions were effective and there are a variety of factors that might have affected this, including exposure incorporating self-reporting results or increased goal proximity. There is a potential that those intervention were effective because they used a short term duration for the intervention. Also, it is clear that SNS are not effective at changing behaviour and losing weight long term period as assessed during the follow-up period. The reason is not clear but it may be due to burden of the participants (Williams et al., 2014)

This review is consistent with similar reviews which investigated the use of social media and SNS to change health behaviour which have largely concluded that interventions incorporating SNS showed a modest effectiveness in influencing health behaviour change (Laranjo et al., 2014; Williams et al., 2014). However, these previous systematic reviews (Laranjo et al., 2014; Williams et al., 2014) differed from the current review in other ways. Firstly, the authors considered health behaviours and their consequences or associated cognitions (e.g. dietary awareness) as outcomes in previous reviews (Williams et al., 2014; Laranjo et al., 2014), whereas in the present review, the focus was primarily on health behaviours. Secondly, the literature searched for this review was clear on health domains with interest limited to particular populations and setting (young adults, university students). Thirdly, the Cochrane Collaboration's 'risk of bias' tool was employed to identify those studies with a higher risk

(Higgins, 2013). Fourthly, the previous systematic review evaluated the influence of social media in changing health behaviour, promotion for health and health communication, resulting in no definitive conclusions regarding effectiveness of the intervention but showing feasibility. Finally, it is worth bearing in mind that social media is a much broader idea than the concept of SNS and can also include blogs and wikis among other intervention components and underlying theories which results in more studies and findings (more follow up period, many different countries, and variation ways to deliver the intervention) compare to the recent systematic review (Williams et al., 2014).

Moreover, online SNS can provide a social support network for people seeking to change health-related behaviours and provide an easy way of connecting with others who have similar goals and beliefs (Williams et al., 2014). Young adults reported that using social media to post about weight-related information was socially undesirable, which may explain why participants did not have high levels of engagement with social media other systematic review compare to the recent review which included only SNS: the reason might be due to different issues of using social media for sensitive and potentially stigmatizing subjects such as weight loss and obesity to share with general population (Williams et al., 2014). For example, many of the included studies' authors stated in the methods that the social media channel was intended for use as social support; however, when examining the process evaluation or engagement metrics, this may not have been used as intended with limited engagement and conversations. This confirms findings from the recent systematic reviews exploring that SNS more effective as tools or apps than social media for obesity prevention in adults (Williams et al., 2014).

Strengths and limitations

This study has several strengths including that a rigorous and pre-defined protocol was followed. All sources and the methods used to evaluate them are openly available. An academic librarian helped ensure a high quality and broad scope to the search of the literature. Studies selection was based on high standard criteria to avoid selection bias, using a pre-tested screening form. Finally, utilization of the Cochrane Collaboration 'risk of bias' tool to appraise the included studies (Higgins, 2013) allowed this study to interpret results within the context of their quality. However, as limitation due to the small number of studies included in the present review, it was not possible to conduct a meta-analysis to calculate the effect size and only full-text was independently screened.

Conclusions

With the increasing popularity of social networking and rising levels of obesity, a clear understanding of SNS use in influencing obesity prevention among young adults is important. This systematic review has shown that health interventions based on social networks combined with other components are potentially useful in helping university students to prevent obesity. Further research is required to evaluate meta-analytical power and determine the real effectiveness of social networks in different contexts.

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Table 2.1: PICOS Criteria for the question of this systematic review

PICOS criteria	
Setting/population	Fulltime university students
Intervention	Information, videos, consulting and messaging through social network sites
Comparison	Control group or other type of social networks
Outcomes	Weight loss in terms of achieving healthy body weight or BMI reduction

Table 2.2: Summary of the RCT studies included in this review

Author, year, Country	Duration of the study and follow up period	Target population; setting	Primary outcome measure	Objectives	Social networks intervention description; (Dose/intensity of intervention)	Way of deliver SN intervention	Main Results
(Dadkhah, 2013), USA	-Intervention = 7 months -Follow up period = 7 months	Healthy 1 st year students I group (n = 120), C group (n = 120); University ^a	Primary outcome: Weight gain prevention: Secondary outcome: Change in eating and activity behaviours	To assess the effectiveness of weight gain prevention programme delivered by an interactive FB providing daily educational information	Students were randomly assigned, to the intervention group interactive FB page with resources or the control group. ; (Daily with mentioned for number of posts).	Delivered by an interactive Facebook page providing daily tips, news articles; educational Web sites, pages, images, and short texts that supported the daily tips	No difference for changes in dietary behaviours or in weight changes between groups
(Gow et al., 2010), USA	-Intervention = 6 weeks -Follow up period = 3 months	Students taking psychology courses (n = 159) 1) C n=40, intervention groups 2) n=40, 3) n=39, and 4) n=40 ; University	Primary outcome: Reduction of BMI Secondary outcome; Improved dietary behaviour.	To evaluate an Internet intervention to prevent weight gain among students	Students were randomly allocated to one of four groups: 1) no treatment, 2) 6-week on-line intervention 3) 6-week weight and caloric feedback only (via email) and 4) 6-weekcombined feedback and on-line intervention; (Weekly with intense exposure)	Delivered by an interactive e-mail reporting information and providing written feedback with face to face session on progress of weight loss	Combined intervention group had lower BMI at than the other 3 groups at 6 weeks. This online intervention demonstrated the effectiveness and feasibility of online intervention at preventing weight gain ^b

Author, year,	Duration of the study and follow up period	Target population; setting	Primary outcome measure	Objectives	Social networks intervention description; Dose/intensity of intervention	Way of deliver SN intervention	Main Results
(Hansen, 2013), USA	-Intervention = 8 weeks -Follow up period = not mentioned	Healthy 1 st year female students (n=30), FI group (n=10), PI group (n=10), C group ; University ^c	Primary outcome: Significant reduction of BMI at beginning of intervention. Secondary outcomes: Increased physical activity and improved eating behaviours.	To assess the effectiveness of implementation of technology alone vs. technology and in-person contact in a physical activity-based 8 week obesity prevention program	Students were assigned to the intervention group weekly group attendance with daily contact using technology, partial intervention weekly group attendance with weekly technology contact. Control group; (Weekly With no mentioned number of posts)	Delivered by an interactive blackboard and reporting written information	No differences in intervention and partial intervention groups using face-to-face and technology methods. Higher compliance in both than the control group. The intervention was not effective in achieving BMI and weight reduction.
(Kattelman et al., 2014), Australia	-Intervention = 10 weeks -Follow up period = 12-months	students from 13 campuses(n=1639), I group (n=824), C group (n=815) ; University	Primary outcome: Weight and BMI reduction, increase FV intake PA & perceived stress Secondary outcomes: Dietary & behaviour changes ^d	To investigate the effects of a theory-based web delivered intervention on weight status over 15 month RCT delivered via Internet and e-mail.	Students were randomized to Intervention group access to personalised web site giving access to 21 mini educational lessons and e-mail and control group; (Weekly intensive intervention)	Delivered by e-mail with providing 21 mini written educational lessons	No difference in weight change or BMI between groups. Intervention supported positive changes in behaviours that mediate excessive weight gain, such as increasing FVI and more healthful self-regulation mealtime behaviours

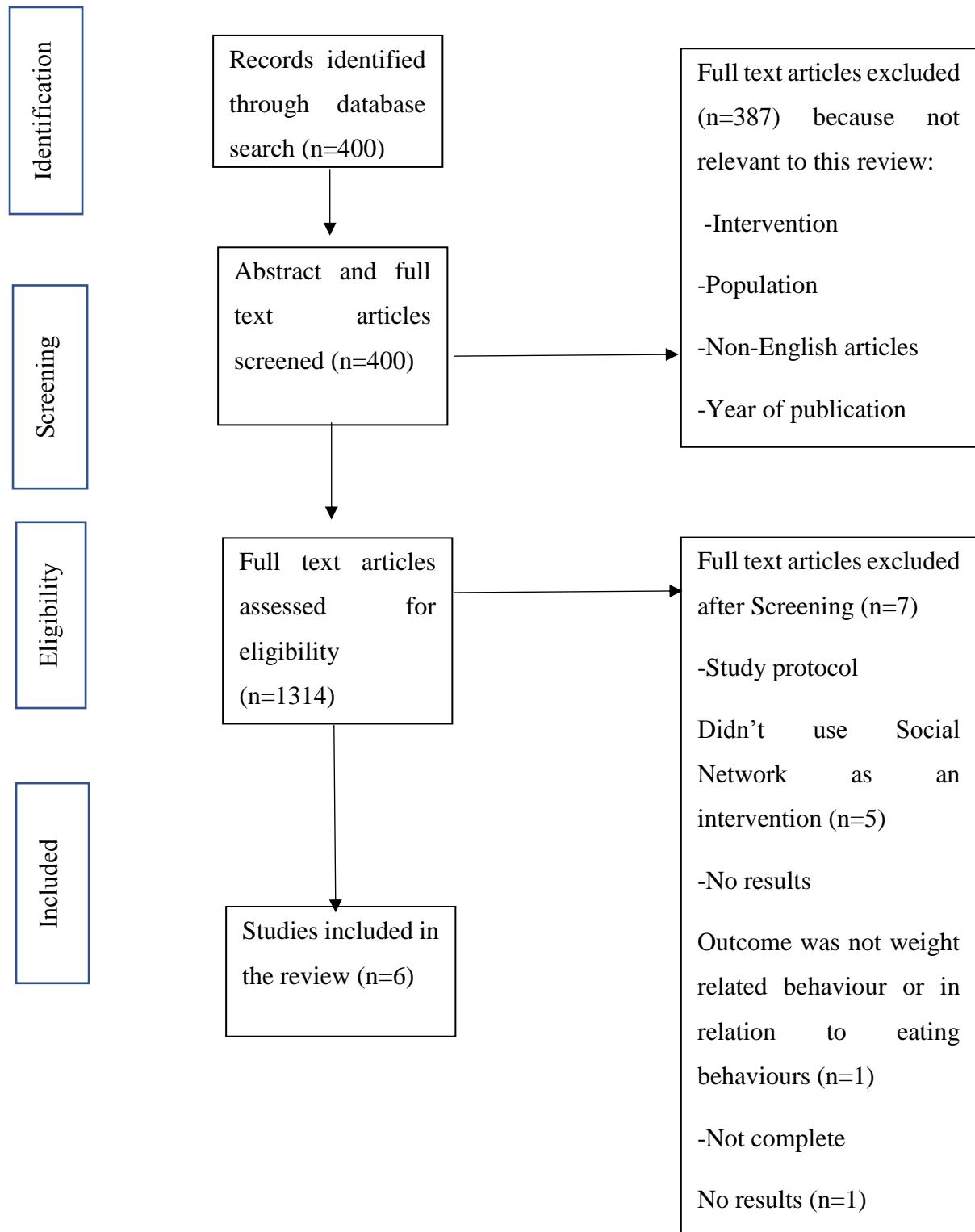
Author, year,	Duration of the study and follow up period	Target population; setting	Primary outcome measure	Objectives	Social networks intervention description; Dose/intensity of intervention	Way of deliver SN intervention	Main Results
(Napolitano et al., 2013), USA	- Intervention = 4 weeks -Follow up period = 8 weeks	Overweight and obese students (n=52), F group n=17, FPT group n=18, C group n=17; university*	Primary outcome: Weight loss after 8 weeks (post-treatment) Secondary outcome: Goal setting and planning, weight self-efficacy, adapted social support for diet and exercise, FB engagement and consumer satisfaction in the programme.	To evaluate the feasibility and acceptability, and initial efficacy of a technology-based 8-week weight loss intervention (FB + text messaging) among university students.	Students were randomly allocated to FB; FB Plus text messaging and personalized feedback; control with assessments at 4 and 8 weeks (post-treatment); (Weekly with no mentioned number of posts)	Delivered by Facebook page with providing video, written nutritional information, written feedback.	At 4 weeks, the FB Plus group had significantly greater weight loss than the FB and control groups. Weight change at 8 weeks was not significantly different between the Facebook and control groups.
(Seely, 2013), USA	- Intervention = 8 weeks -No follow up period	Overweight or obese students n= 24, I group n= 11, C group n= 13 ; university	Primary outcome: Weight loss after 8 weeks (post-treatment) Secondary outcome: Increasing self-efficacy	To determine if use of a FB support group in combination with a one-time weight loss class will increase the likelihood of students achieving weight loss and lifestyle goals	Students were randomly allocated to Intervention FB support or control group. All students were enrolled in one hour weight loss class and received nutrition education; (No mentioned number of posts and dose)	Delivered by Facebook with providing written nutrition education and information	No difference in weight loss between groups .However overall mean weight loss was greater in intervention than controls

^a I=intervention group, C= control group; ^b BMI=Body Mass Index; ^c FI=full intervention group, PI=part intervention group; ^d F&V=fruit and vegetables, PA= physical activity; * FBT= Facebook plus text message group.

Table 2.3: Risk of bias assessment of the 6 studies included in the review

Author, year	Sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective outcome reporting	Other
Dadkhah, 2013	Low	Low	Unclear	Unclear	High	low	High
Gow et al., 2010	Low	Unclear	High	Low	Low	Low	High
Hansen, 2013	High	High	High	High	High	High	High
Kattelman et al., 2014	Low	Low	High	Unclear	High	High	High
Napolitano et al., 2013	Unclear	Unclear	High	Low	Unclear	Low	Low
Seely. 2013	Low	High	Low	High	High	High	High

Figure 2.1: (PRISMA) Flow diagram of studies selection



Chapter 3

A qualitative study to explore factors which influence eating behaviours of university students when living away from home

Abstract

Background

The transition from high school to higher education has been recognised as a time when students are susceptible to developing unhealthy eating practices. It is a time when students encounter difficulty in sustaining a healthy lifestyle due to their newly-acquired independence, the influence of new friends and financial restrictions. Therefore, eating habits developed during this time may affect their health that can last well into adulthood.

Objective

This study aimed to explore the eating behaviours and experiences of students attending university in Northern Ireland to collect ideas and recommendations to inform the development of an RCT aimed at improving healthy eating behaviours.

Methods

Full-time students living away from home were recruited following a university-wide e-mail. Local and international students across all study subjects and each campus (n=4) who expressed interest were invited to participate in a facilitated focus group discussion. A semi-structured topic guide was used to discuss relevant factors influencing eating behaviours in both undergraduate and postgraduate university students who lived away from home for four nights or more. All group discourse was audio-taped, two researchers independently analysed verbatim transcripts for emerging themes, using an inductive thematic approach for analysis.

Results

A total of 42 students aged ≥ 18 years (n=27 male; n=15 female) comprising undergraduate (n= 17) and postgraduate (n=25) students, mean age 23 (SD 5.3) years, mean BMI 24.5 (SD 4.6) kg/m² participated in eight facilitated discussions. Three key themes were identified as

influencing eating behaviours. These were: *nutritional awareness and knowledge* (nutritional labelling, menu preparation, cooking skills) *and knowledge, personal factors* (taste preferences, time, convenience, religious beliefs, peers) and *physical factors* (availability and accessibility, cost of food, accommodation facilities, academic stress). (In addition suggestions for improving healthy eating behaviours were discussed and included providing nutritional information and advice on healthy meal preparation (e.g. FV in daily meals). Students reported favouring the use of social network sites (FB) to deliver nutrition education (for and short cooking teaching sessions as means of delivery). Conclusion

Findings of this current study show that students are influenced by factors unique to university settings for example accommodation facilities, academic pressures and lack of finances and highlighting the importance of understanding the determinants of eating behaviours in young adults to influence healthy dietary behaviours. These key themes, together with findings of systematic review were used to develop a social network intervention aimed at influencing and changing eating behaviours of such university students.

Introduction

The transition from school to university has been recognised as a vulnerable period for increasing body weight and the development of obesity with males and females reportedly gaining between 3 to 4.4 kg during the first year (Kelly et al., 2011; Napolitano et al., 2013). Many students face difficulties maintaining a healthy lifestyle when living away from home for the first time, with increased freedom, establishing new friendships, managing finances and the temptation to develop adverse weight-related behaviours (e.g. poor dietary intake, inactivity and increased alcohol consumption) as they adapt to student life (Bray and Kwan, 2006; Strong et al., 2008). Previous studies highlight key factors to adversely impact on healthy eating habits include limited food choices, lack of availability of inexpensive healthy food, limited cooking skills and lack of facilities to store and cook food, all of which result in consumption of processed foods and snacks (Bray and Kwan, 2006; Strong et al., 2008). Similarly, excessive intake of energy-dense, high-fat foods occurs during periods of stress and when funds are limited (Zellner et al., 2006). Recent evidence from surveys of students both in USA and UK have concluded that the typical university student's diet is generally low in vegetables, fruits, and dairy products and higher in fat, and sugary foods (Brunt et al., 2008; Zellner et al., 2006). This leads to poor nutritional and unhealthy diet with the likelihood of weight gain, leading to development of obesity. This study concurs with a study from Greece where university students were found to have significantly higher intake of total and saturated fat and lower intake of poly- and mono-unsaturated fat, folate, vitamin E and fibre in their diets (Chourdakis et al., 2011). Furthermore, Holm-Denoma et al (2008) showed that university students are at risk of gaining weight more quickly than a person of the same age who is not attending university (Holm-Denoma et al., 2008). Thus, dietary behaviours of students may influence dietary habits for the future and lasting well into adulthood (Bray and Kwan, 2006; Strong et al., 2008). It is

reported that these dietary behaviours are influenced by student characteristics including social and environmental determinants (Deliens et al., 2014). However, within Northern Ireland no evidence exists hence, this study aims to explore the factors and experiences of university students which influence eating (and alcohol) behaviours when living away from home. Data collected will provide baseline information on the current students in one University in Northern Ireland which will be used to develop an RCT (Chapter 4) to influence eating behaviours.

Study overview and ethics

The study took place between January and February 2016. The ethical approval was obtained from Ulster University Research Ethics Committee.

Study protocol and methods

Full-time university students (18 years of age or older) were recruited from Ulster University to participate in a focus group to explore the experiences which influence their eating habits. Each focus group comprised of five to six students from both EU and non-EU backgrounds. Focus groups were held on all (n=4) university campuses, determined by student preference. As it is not possible to pre-determine the sample size in qualitative research, focus groups discussion were carried out until a saturation level was obtained (it was estimated that it would be completed by 6 to 7 focus groups). This estimation was derived from a similar study (Deliens et al, 2014) which allows for 10% drop out. Recruitment was undertaken using 2 methods: e mail and face to face. An e-mail (Appendix 3) was sent to all registered students in Ulster University asking for interested participants. In addition face-to-face method was used whereby the researcher promoted the study in the foyer of each campus and discussed participation with interested students. A participant information sheet (Appendix 3) and consent form were included in the recruitment email to ensure the students received it before completing the screening questionnaire. A short online screening questionnaire (via SurveyMonkey®) was completed by students who had expressed an interest in participation. As part of this screening questionnaire, (Appendix 3) students were asked to provide details relating to their age, campus attending, living status and number of nights they usually live away from their family home. Students were also asked to provide contact details for the researcher to arrange participation in a focus group convenient for them. Background data collected was utilised to determine potential participants according to gender, nationality, and course registered for. To ensure diversity in the range of individuals asked to participate. Each consenting participant received

an e-mail one week before the focus group to remind them of time, date and venue and to answer any queries.

At the beginning of the focus group consent forms were obtained, participants were asked to complete a short demographics questionnaire which asked participants to self-reported height and weight (in order to calculate body mass index (BMI, kg/m^2) and year of study. An observer from the research team attended on all focus groups and recorded appropriate information to permit relevant information to be linked to background data and provide quality assurance of anonymised data. Participants also completed a consent form for the focus group discussion at this time.

Procedure

Light refreshments were offered during the focus group. Semi-structured focus groups were conducted using a schedule (table 3.1). Each focus group started with the researcher outlining the aim of the study. Subsequently, structured discussions were undertaken to ensure each participant provided their own perspective and experiences with regards eating and lifestyle behaviours when regularly living away from home. A digital recorder was used to record the focus group discussions, whilst an assistant researcher recorded notes which contributed to the analysis to ensure inter-rater compatibility. Each of the focus groups lasted approximately 1-1.5 hours. Mixed groups were used as far as possible to demonstrate a range of gender, nationality and course undertaken.

The following criteria was used to identify students that they are eligible for this study:

Inclusion criteria

- 1-Full time students enrolled at Ulster University.
- 2-Male or female.
- 3-Students 18 years and over.

- 4- European and non-European students.
- 5- On campus and off campus university students living independently from their families.
- 6- First, second and final years students (3rd and 4th year) undergraduate and postgraduate students.
- 7- Regularly living away from home for 4 or more nights.
- 8- Students in all study disciplines /subjects including nutrition.

Exclusion criteria

- 1-Students not enrolled/not registered at Ulster University.
- 2- Members of staff.
- 3-Part time students.
- 4-Students under 18 years old.
- 5- Students who live at home or with their family.
- 6- Students who live away from home for less than 4 nights.

Topic guide

A semi-structured topic guide (Table 3.1) was carefully developed by the research team to ensure that each focus group was run similarly and to ensure the discussion covered the main factors. The structured discussion framework was developed by 2 members of the research team to facilitate discussion and reflection around the overall aims of the qualitative study and reviewed by the third member. The questions were generated using the Krueger and Casey's method for 'five categories of questions' which include an opening question, introductory question, transition questions, key questions and a concluding question. The content of questions was informed by the questions from similar studies in university students (Deliens et al, 2014). Specifically they included questions to explore participants' motivators and barriers to healthy eating. Probes were used to clarify, and explore the topics. The limitation of using a

topic guide is that numerous questions might increase the burden of the participants and prolong the time required to complete the focus groups. However, many questions are required to gain in depth information. Also, in addition some questions (transition part) were leading to encourage discussion by probing and using open ended questions. The topic guide was piloted initially with a separate group of students to test the questions used and confirm the focus. The results of the pilot study were not included in the final analysis of the study. The topic guide included a set of opening questions which facilitated participant familiarity with each other. The key and transition questions were asked to ensure the discussion progressed to the most significant part of the discussion and also to emphasis on the aim of this study to ensure the maximum share of the group discussions on the key questions. Students suggested ways in which healthier eating could be promoted and the types of interventions and tools which would be useful. During the group discussions, the moderator asked the questions in the order provided in the topic guide, in addition extra questions were asked in order to acquire further and more detailed information on the topic when required... Also, the moderator showed sufficient flexibility to permit the students to participate in the discussion.

Data analysis and statistical methods

After conducting the focus groups, the recordings were subsequently transcribed verbatim to Microsoft Word. An inductive thematic content analysis was applied in order to analyse and encode the quotes, and the computer-assisted qualitative data analysis software program Nvivo 10 (QSR International Pty Ltd; Doncaster, Victoria, Australia) was used to categorise common topics and integrates several functions to facilitate the management and analysis of data.

Procedure for inductive thematic analysis

In order to create established and meaningful themes, an inductive thematic analysis approach through the process of coding in six phases was used for the transcription process.

Phase 1: Familiarisation with the interview

A vital stage in interpretation is listening to the audio recording and/or read the transcript and reflective notes that were recorded by the researcher to be familiar with the whole focus group.

Stage 2: Generating initial codes

After familiarization, the researcher carefully re-read the transcript line by line, applying (an initial 'code') which describes what they have interpreted in the passage as important. As an inductive analysis, at this stage 'open coding' takes place, i.e. coding anything that might be relevant from as many different perspectives as possible. Codes could refer to (e.g. values and emotions). Two researchers (AH, AJH) code and independently reviewed first few transcripts. Coding line-by-line were conducted to alert the researcher to consider which may ordinarily remain invisible because it is not clearly expressed. However, coding digitally using Nvivo keeps track automatically of new codes.

Stage 3: Developing a working analytical framework and searching for themes

After coding the first few transcripts, all research team members met to compare the categories they have applied and agree on a set of codes to apply to all subsequent transcripts. Then codes grouped together into categories which are then clearly defined. This forms a working analytical framework. Then, researcher searched for themes and considering what works and what does not work within themes to begin the analysis of potential codes

Stage 4: Reviewing themes and applying the analytical framework

The researcher searched for data that supports or refutes the proposed theory which allows for further expansion on and revision of themes as they develop. The working analytical framework is then applied by indexing subsequent transcripts using the existing categories and codes.

Stage 5: Defining and naming themes

The researcher defined and refined existing themes that will be presented in the final analysis in order to assist in analysing the data within each theme.

Stage 6: Interpreting the data

After final themes have been reviewed, researcher wrote the final report and decided on themes that make meaningful contributions to answering research questions.

BMI was used to categorise body weight status into underweight ($\text{BMI} < 18.5 \text{ kg/m}^2$), normal/healthy ($\text{BMI} 18.5\text{--}24.99 \text{ kg/m}^2$), overweight ($\text{BMI} 25 \text{ kg/m}^2$) and obese ($\text{BMI} 30 \text{ kg/m}^2$) according to the World Health Organisation (WHO) cut-off points of international classification (WHO, 2018). Statistical tests were carried out using the Statistical Package for Social Sciences (SPSS V22). The statistical tests conducted include: descriptive statistics for means and standard deviation categories.

Results

The saturation level was achieved by the eighth focus group which consisting of four to six participants. Participants recruited (n = 42) consisted of 27 male and 25 female students (n=17 undergraduate, n=25 postgraduate) with mean age 23 (SD 5.3) years and mean BMI 24.5 (SD 4.6) kg/m². The majority of students had a background in biomedical sciences (50%) whereas 20% and 14% were studying arts and computing and engineering respectively. Additional sample characteristics are described in (Table 3.2) a framework was developed based on content analysis of the focus group discussions. Three major themes arose in terms of influencing healthy eating behaviours of university students. These themes and the identified sub-themes within each are described below:’

Theme 1. Nutritional awareness and knowledge

Lack of cooking skills and menu preparation

Cooking skills was a consistent theme as many students reported that, when they started the first year of university they had to become independent, and a lack of cooking skills played a significant role in affecting their eating choices. One student mentioned *“I don’t really cook all that much. Probably, I can make pasta and stuff like that but I wouldn’t say I’m very adventurous with cooking so really not great”* (focus group 1, male, undergraduate).

Participants reported that they lacked menu preparation skills required to eat healthy and that most students are aware of ‘what is good or bad for their health’. However a level of dietary knowledge was also believed to improve eating patterns among study participants. One stated *“It’s more the preparation and selection the food which is the difficult part, Like every day you don’t plan to go to shopping and say right I’m preparing to eat healthy food today, it’s more about avoiding unhealthy food and to prepare your list to have healthy food which is difficult”* (focus group 2, female, undergraduate). Another student reported *‘Sometimes you don’t have knowledge, this is healthy and this food is not healthy. Not all of the people, go into*

details about the specifications of this healthy or not healthy, just can't waste time in thinking of preparing a healthy meal. Anything that goes in the oven as a ready meal and has instructions to prepare and comes out and you eat it. That's my ability to prepare the food" (focus group 3, male, postgraduate).

Theme 2. Personal factors

Ethical and moral considerations

Participants reported that eating patterns are affected by the norms, values and even their personal beliefs. For example one student became a vegetarian due to personal beliefs *"I can't eat some food due to my religion, it should be halal, therefore sometimes I am not eating full healthy food, I tend to follow vegetarian diet"* (focus group 4, female, postgraduate) .

In addition, some students stated that eating behaviours fluctuate according to feelings such as guilt occurring after consuming unhealthy food for example *"Like after the weekend I feel ashamed because I ate too much and gained weight, so I tend to eat healthier food in the next day"* (focus group 5, female, undergraduate).

Time and convenience

Time required to prepare and cook food was reported to have a major impact with students as they prefer to spend time being involved in other activities instead of cooking. They agreed that time could be considered as a relative term, often related to how one prioritizes their activities. One student stated that, while living on campus, *"Time is a big issue. Like, some people just want quick and just you're hungry also by the time you come out in the evening as well because you've been sitting in the lecture theatre for so long, you just put whatever you get and you just want tasty food, you really don't think about it"* (focus group 6, male, undergraduate). They also stated that ease and convenience, which is related to time, is a

significant factor is meal preparation time and that especially during exam periods it becomes important.

Finance

Money can be an obstacle to healthy eating choices for some students. Many students reported that buying food for one person was more expensive and that shopping in smaller local supermarkets were also more expensive. *“I think especially us and like in an unpaid placement we have to be careful with money and we do have to work out how much money for fuel and food so you need to kind of think methodically about what you’re having for dinner”* (focus group 6, male, undergraduate).

Influence of existing habits

According to participants, many had existing eating habits before coming to university which continued to have an influence on their food choices for example *“For me, when I was in my country I used to eat unhealthy food, fast food, I don’t know, maybe it is like a habit, so I do the same here”* (focus group 1, female, undergraduate).

Peer influence and perceived enjoyment

The majority of participants talked negatively about the influence of their friends and the pressure they face when they go out with them with regards eating healthy as a competing demands *“It’s hard, it depends on the social culture of each country, for example, I live with my flatmates from USA and they used to make fast food delivery, they don’t cook at home so it’s pretty hard when it’s food in the kitchen’*. Another student said *‘Most of the time I try to eat healthy but obviously there’s times I fancy chocolate or something after dinner’* (focus group 7, female, postgraduate).

Theme 3. Physical factors

Food availability and accessibility

Some students found that temptation to unhealthy food choices increased with easier access to fast food outlets. *“I used just to ring Pizza shop every day or go to fast food shop or whatever and I don’t like that kind of food but because I did not have enough time and I don’t want to go to the street waiting for the bus I just came home from the university really tired”* (focus group 8, male, postgraduate).

Cooking facilities

Availability of appropriate cooking facilities in accommodation was highlighted as a barrier to eating healthy. For example health and safety policies in shared accommodation was reported as being an issue for example *“This accommodation culture so it’s like people who are bossy, they’re very strict about keeping the kitchen clean and hygiene is very, very important but they’re too strict, like student got fined for one splash on the kitchen floor or to use the kitchen after 11 pm”* (focus group 2, male, undergraduate).

Academic environment, including exam stress

The majority of participants reported that stress as a competing demand during university for example exam periods and submission deadlines for coursework influenced their eating habits. Stress had different effects with some students eating healthier, whilst for some, eating behaviour worsens during high stress levels. *‘I, actually gained weight here because I think regarding the stress of the exam and regarding stress of study you need something to run away from it sometimes you –just eating. yes, just eat for eat, even you are not hungry’*. (focus group 5, female, undergraduate).

Recommendation for future interventions

Participants suggested that face to face communication is preferred for promotion of healthy eating and raising awareness. Students also suggested the use of social networks in providing nutritional information *“Information with photos through Facebook, because the photos always look better, It’s a good idea if you can post some information, or like or if there’s a system you can have some details on students away from the home, you can contact them by Facebook, send some text message or short awareness message for them every week or every month about healthy habits, about the healthy food, maybe it will support them, will give them some knowledge and maybe will push them to have confidence”*. On the other hand, a few students mentioned”. *“Yes, sometimes, face to face is more affective if you receive something, messages, or in your Twitter account or in your Facebook message or something about good habits and healthy food, sometimes, if you read it, it will not be affective, more than face to face. When you see an expert person talking to you, giving you the impression he is aware of your health and something like this, and he want to try to help you and support you, even especially if you have a problem with this issue”*.

Discussion

This qualitative study aimed to elicit the factors which affect healthy eating behaviour in university students. A further objective was to gather ideas and make recommendations to facilitate the development of an RCT designed to promote healthy eating habits could be promoted in university students. Three major factors identified as affecting healthy eating behaviours of students were: *nutritional awareness* (nutritional labelling, menu preparation, cooking skills) and *knowledge, personal factors* (taste preferences, time, convenience, religious beliefs, and peers) and *physical factors* (availability and accessibility, cost of food, accommodation facilities, and academic stress). In addition, a few university-specific aspects were observed to have influenced eating behaviour which are more important after the transition from school to university when independency increases and they have responsibility for food preparation as they live away from home. For instance, as previously documented in US literature (Greaney et al., 2009; LaCaille et al., 2011; Nelson et al., 2009; Cluskey and Grobe, 2009), our participants cited intrinsic influences (such as food preferences), extrinsic influences (such as guilt, health awareness), motivation and time management as factors which affect healthy eating patterns. It was evident from our results that these factors become more significant at transition from secondary school to university when independence increases.

Following a systematic review of effectiveness of dietary interventions in college students, Kelly et al (2013) proposed that strategies including self-regulation approaches can help in developing changes in dietary intake of students (Kelly et al., 2013). Although Cluskey and Grobe (2009) found that most students were in need of internal motivation to successfully move towards healthy behaviour, the outcomes showed that the overall environment should be such that it forces students to select healthier food options (Cluskey and Grobe, 2009). Food selection by students is also affected by availability and accessibility of healthy foods and cooking skills also play a role (Greaney et al., 2009). Similarly, the present study found that

students will select healthier options if they are available in local shops close to accommodation and when available on campus catering facilities. This would assist in providing variety and giving students the option to choose healthy foods suggesting that healthy meals in the university canteens and the shops in close proximity should look more tempting as it can inspire selection of healthier choices by university students (Hearn et al., 1998). This finding was in agreement with the findings of Deliens et al (2014) who found that university characteristics and environmental determinants influenced eating behaviours.

In the present study, students reported feeling that they are constantly facing competing demands including academic requirements (e.g. exam periods and submission deadlines for assignment) and participation in social and extracurricular activities (e.g., going out with friends and flatmates) to spend time planning healthy food choices. Healthy food choices were reported as less important by students when compared to academic pressures for example exam stresses and also when finances were limited. Students are therefore more likely to buy cheaper fast foods which are convenient, suggesting that they prioritise convenience and cost over healthy. This finding concurs with Nelson et al (2009) who suggested that selection of healthy food is low priority when compared with other responsibilities (Nelson et al., 2009).. For this reason, as highlighted by the participants in the present study, there may be a greater possibility that students will select foods that are fast, cheap, and convenient. Marquis et al (2005) reported that college students usually give priority to convenience and cost over health (Marquis, 2005). Others report that after taste, another factor influencing food selection is its cost and in other studies this has applied to adults and adolescents alike (Shannon et al., 2002; French et al., 1999; French et al., 2001; Glanz et al., 1998; French et al., 1997). This present study showed that provision of healthy food at a cheaper price on campus may support students in choosing healthier options. As cost is a major factor for students' choice of food, a subsidised approach to promoting healthier eating or special promotions may encourage students to change habits.

Students also felt that having dietary information is the initial step towards understanding how to change eating habits. Cluskey and Grobe (2009) reported that university students are not aware of, and do not have the skills to, make healthier food selections or how to prepare food (Cluskey and Grobe, 2009). This deters them from adapting a healthier lifestyle in college or university. Participants in the present study proposed that a short nutrition education class should be taught in colleges and universities. Furthermore, findings from the present study also suggest that food consumption appeared to be influenced by the students' parents and type of household.

Parents are role models for eating patterns of their children and their dietary behaviour are apparent during this time (Deliens et al., 2014). The latter indicates that those university students who reside with their parents can have similar parental influence. In addition to family influences, participants consider that friends and peers also have an impact on eating patterns. A study by Shannon et al (2002) suggested/found that food choices of adolescents were affected by attitudes, behaviours and encouragement of friends and peers. Eating behaviour was also affected by living arrangements and exam time (Brevard and Ricketts, 1996; Brunt et al., 2008; El Ansari et al., 2012). In a study involving four European countries, more fruits and vegetables were consumed by students living at home than those living away (El Ansari et al., 2012). Moreover, Kapinos and Yakusheva (2011) indicated that more weight was gained by students who were allocated space in dormitories including on-site dining halls than students who were not assigned these dormitories (Kapinos and Yakusheva, 2011). The link between eating habits and influencing factors could be moderated through living arrangements instead of leading to any specific eating pattern. MacKinnon et al (2007) stated that the strength of a link between two variables is influenced by a moderator. For instance, a student staying in a student residence could moderate the association between eating pattern and influence of

parents, meaning control of parents reduced when students are living away from home (MacKinnon et al., 2007). Similarly, in this current study, the association between eating pattern and parental control was shown to be stronger in students who live at home in comparison to those living away from home. Moreover, these outcomes showed that, when students live in student residence and receive a specific weekly allowance, food prices play a significant role in food choices, suggesting that students focus on buying the essentials. Therefore, for students living away from home, a stronger association between price of food and eating behaviour can be evident when compared to students residing with their parents.

Exams can also have an impact on the link between, for example, time and eating pattern. According to the present study, students spend very little time cooking during exams which is similar to US studies (Greaney et al., 2009; LaCaille et al., 2011). For example, in an American study, US students refer to the plentiful availability of fast food and ‘one dollar menus’ when compared with Europe (Greaney et al., 2009; LaCaille et al., 2011). Through focus group discussion with those US students, a negative effect on healthy eating patterns due to the all-you-can-eat deals on on-campus dining facilities was identified.

One significant element of this explorative research is the qualitative research methodology including use of focus groups. Sallis et al (2006) suggest that through qualitative research one is able to comprehend not just the “what”, but also the “how” and “why” of a topic (Sallis et al., 2006). This study developed a student specific framework by implementing an inductive thematic methodology. Moreover, a “naturalistic” methodology which means (more like daily conversation between students in the real academic life) was adopted in place of in-depth interviews. It included dynamic group interaction which helped us obtain better information regarding the factors which affect eating patterns of university students. This may help reassure some participants who could be apprehensive of the group environment where their thoughts or perspective could be very well recognised.

Limitations in the current study arise from the fact that participants were students in Ulster University and other students from Higher education institutions were not included. In addition participants volunteered to come to a focus group and were willing to talk and that this could have led to selection bias. Nevertheless, adequate diversity in BMI and perceived health status was evident in the sample characteristics.

A second limitation was the differences in behaviour by gender or the year of study in university but focus groups of mixed genders were selected from different years and fields in the university (Boek et al., 2012). This allowed to initiate interaction among both genders, including various study experiences and backgrounds.

No conclusions could actually be drawn regarding the significance of each determinant and whether results could be generalized due to the limitation and the explorative nature of this research. Focus groups were conducted to achieve detailed understanding of beliefs and experiences of participants and not for generalization of outcomes (Morgan and Krueger, 1998). Furthermore, an issue being identified more frequently does not necessarily mean that it is of greatest importance even if it is raised by a large number of people (Laranjo et al., 2014). This means that each perspective or idea should be equally considered. Thus, in future research, a larger representative sample size should be included with emphasis on provision of quantitative evidence about the significance and value of each theme. Through this, it should also be possible to distinguish issues by year of study, gender, study discipline or other student factors. Consequently, emphasis of future, customized interventions could be on factors which students consider to be the most significant in their recent dietary behaviour. Observed outcomes of the present research is in agreement with Deliens et al (2014) who found that factors which impact on the student's healthy eating behaviours need to be overcome in order to help students moderate their eating behaviours (Deliens et al., 2014).

Conclusion

To develop effective healthy eating strategies in university students it is important to understand why and how students' eating behaviours are influenced during their time at the university. This present study has identified constraints to behaviour change and potential support mechanisms to help them achieve a more healthy diet. This qualitative study has identified three key themes as influencing eating behaviours. These were: *nutritional awareness* (nutritional labelling, menu preparation, cooking skills) and *knowledge, personal factors* (taste preferences, time, convenience, religious beliefs, and peers) and *physical factors* (availability and accessibility, cost of food, accommodation facilities, and academic stress). *In addition* students are influenced by factors unique to University settings for example accommodation facilities, academic pressures and lack of finances and that independence increases and students are faced with more challenges with regards making healthy food choices and therefore they often may have to prioritise food choices over other demands on their activities for example healthy food choices were reported as less important by students when compared to academic pressures for example exam stresses and also when finances were limited. Students are therefore more likely to buy cheaper fast foods which are convenient, suggesting that they prioritise convenience and cost over health. With the significant transition for students moving to university, this study indicates that independence increases and students are faced with more challenges with regards making healthy food choices and therefore they often may have to prioritise demands on their activities over other food choices. Results of this qualitative study has provided evidence that three major factors largely contribute to decisions regarding healthy eating behaviours of students. This study also identified recommendations as to what methods students would prefer to use to become more knowledgeable on food choices. Therefore results from this study has identified the main factors reported by students as to influence food choices and will inform the development of

an RCT to develop an intervention aiming university students. Both the key themes and students' recommendations evolving from this study and the findings of systematic review, are being used for developing of an intervention aimed at influencing eating habits in university students who live away from their families and home.

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Table 3.1: Focus group topic guide

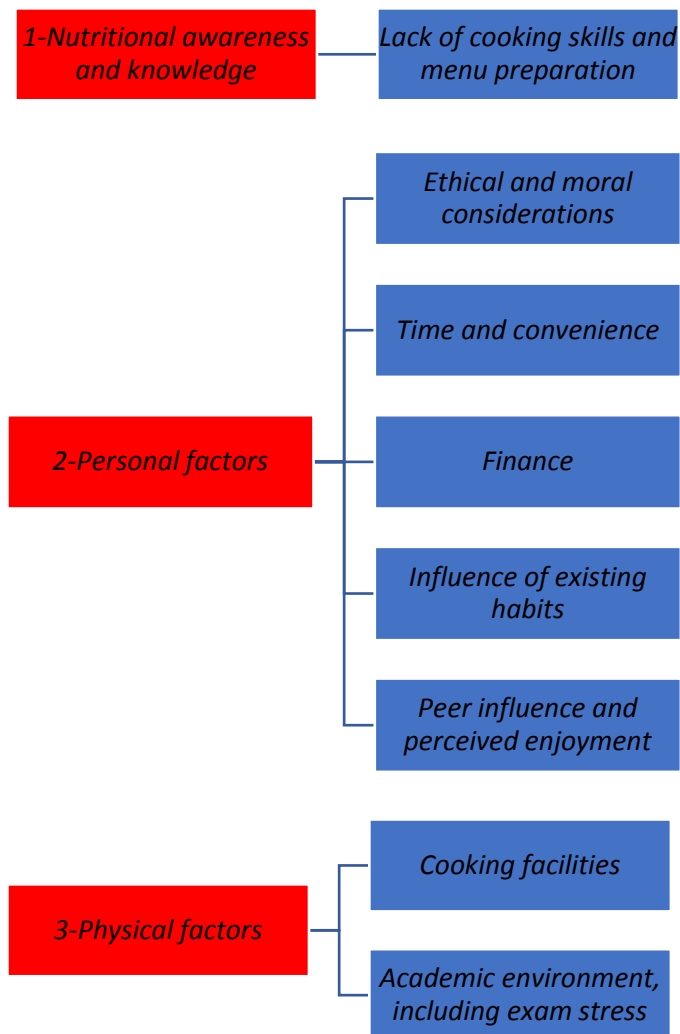
Question type	Question
Introduction	<p>1. Can I ask you all to briefly introduce yourselves to the group: (course, year of studies?)</p> <p>2. How would you describe a healthy person/student? What do you understand by this?</p>
Transition	<p>3. What comes to your mind when we think about ‘health in university students’? What do you think healthy means? Do you think about your weight? Or is it being active? Or getting enough sleep?</p>
For (2nd and final (3rd and 4th)) year students	<p>4. a- Think of the last year(s) being a university student. Did your body weight change since you entered university? What are the reasons for a change in your weight? Did you gain weight or lose weight during semesters?</p>
For first year students	<p>4. b- Has your weight changed, during the last months, since starting University? What are the reasons for a change in your weight?</p> <p>5. How would you describe your cooking skills? Do you cook meals? What type of foods do you cook? What are the reasons that stopping you from cooking?</p> <p>6. Is it expensive to buy food from shops for one person? Do you find it difficult to get time to shop? Is it difficult to get a bus to the shops? Do you budget your money for food? Does that influence your eating behaviour?</p>
Key questions	<p>7. Has your alcohol intake changed? Do you drink more alcohol whilst living away from home?</p> <p>8. Which factors do you think might have caused these changes (or which factors influence your current health behaviours)? What do you think are the barriers to eating healthy?</p> <p>9. Which of the previous mentioned factors have had the greatest influence?</p>
Ending	<p>10. Do you use social network sites (e.g. Facebook)? For what or why do you use these? What examples of social network sites regularly you use?</p> <p>11. Following this focus group we aim to develop an intervention to help students make healthier choices. Can you give us some advice on how to promote healthy eating behaviours in students or what tools do you think would be useful for students? (e.g. through social network, nutritional tips or cooking skills)</p> <p>12. Do you think social media or social network websites would be useful? If so what would encourage you to participate in an intervention?</p> <p>13. Is there anything that I have missed – have you anything else you can suggest or add to our discussions regarding healthy eating for students and how best to improve the health and knowledge of students whilst at university?</p>

Table 3.2: Sample demographics

Variables	(%, Mean, SD)
Gender (%)	
Male	64
Female	36
Year of study (%)	
Undergraduate	40
Postgraduate	60
Age (years)	23 \pm 5.3*
Body Mass Index (kg/m ²)	24.5 \pm 4.6 ^
Nationality (%)	
British/Irish/UK	40
Other European	5
Non-European	55
Study discipline (%)	
Biomedical sciences	50
Social sciences	6
Arts	20
Computing and engineering	14
Business	10

SD=standard deviation; *^Values are presented as mean and stander deviation; All other values presented as percentage

Figure 3.1: Three factors identified as affecting healthy eating behaviours of students



Chapter 4

The influence of Facebook to increase fruit and vegetable consumption in university students: A randomised controlled study

Abstract

Background

The transition from post-primary school to third-level education has been recognised as a vulnerable period for the development of unhealthy eating behaviours of university students that may have long-term health implications lasting well into adulthood. Evidence from both the USA and UK have shown that the university students' diet is generally low in fruit and vegetables (FV) which might lead to poor nutritional intake and weight gain.

Objectives

This study aimed: 1) to deliver and evaluate a nutrition intervention aimed at increasing FV intakes of university students living away from home, 2) to investigate the impact of providing 5 portions of FV weekly on biomarkers of FV intakes in students living away from home and 3) to investigate whether FV consumption was further enhanced when Facebook (FB) messages providing nutritional education were also used.

Methods

Full-time university students were recruited from Ulster University Coleraine Campus and randomly assigned to one of three groups: *Control group* were asked to maintain their normal diet; *F&V group* provided with five portions of fruit and vegetables daily for 4 weeks based on individualised preferences; *F&V + FB group* provided with FV (as for the *F&V group*) and in addition received daily nutrition messages using FB aimed at increasing knowledge of FV. FV intake was assessed pre and post intervention using a validated 4-day semi-quantitative food diary. Compliance with consumption of FV provided was assessed using records of uneaten FV which was returned to researchers. Nutritional analysis of food diaries was undertaken using Nutritics software.

Results

Participants at baseline had a mean age of 24.4 (SD 3.7) years and mean BMI of 25.4 (SD 4.7) kg/m². Study groups did not differ by age, however they did differ by gender balance (24 male and 36 female, $P=0.003$), BMI ($P=<0.039$) and TEI ($P=<0.041$). Consumption of FV increased in both intervention groups ($P=<0.001$) from baseline to end of study with food diary (4DFD) data showing that there was a significant difference ($P=<0.001$) in the intake of both intervention groups compared to the control group with mean difference of 2.2 (1.2) *F&V group*, 2.2 (1.5) *F&V+FB group*, and 0.1 (0.5) control group suggesting that 31% of participants in both intervention groups consumed 5 portions of FV each day. While, data from 'return bags' suggested 65% achieved increased of FV in both intervention groups ($P=<0.001$) from baseline to end of study of 4.6 (0.6) *F&V group*, 4.7 (0.4) *F&V+FB group*. However, the provision of F&V with or without FB did not have any enhanced effect on FV consumption and was not sustained at 3 weeks after the end of the intervention. Of those 20 participants in the *F&V + FB group*, 70% engaged with FB regularly with 35% classified as highly active, 15% moderately active and 50% minimally active

Conclusions

This study demonstrated that daily consumption of fruit and vegetables increased from 1.6 portions a day to almost the recommended level of intake 4.6 with mean intake of 2.2 (1.5) portions when F&V was provided free of charge. In addition providing nutrition education using FB reinforced the 5-a-day message and provided practical solutions and tips to increase consumption, however, providing additional nutrition education support via FB was insufficient to increase consumption.

Introduction

The transition from school to university has been recognised as a vulnerable period for development of overweight and obesity with males and females reportedly gaining between 3 and 4.4 kg during the first year (Kelly et al., 2013; Napolitano et al., 2013). Many students face difficulties adapting and maintaining a healthy lifestyle when living away from home for reasons such as increased freedom of choices, peer pressure, financial constraints and development of adverse weight-related behaviours (e.g. poor dietary intake and inactivity). Dietary behaviours developed during time as a student may have major long-term health implications lasting well into adulthood. Factors reported as negatively impacting on healthy eating behaviours include limited availability and choice of inexpensive healthy food, lack of cooking skills and facilities to store and cook food which can lead to consumption of processed foods and ready meals/snacks (Bray and Kwan 2006; Strong et al., 2008). Moreover, evidence suggests that intake of energy-dense high fat foods increase at periods of stress and when money is limited (Zellner et al., 2006).

The World Health Organization (WHO) recommends minimum intakes of 400g of fruits and vegetables per day (WHO, 2012) which is 5 portions of approximately 80g/portion. Recent evidence from surveys of students both in the USA and UK have shown that the typical university students' diet is generally low in FV and high in fat which leads to poor nutritional intake and weight gain leading to development of obesity (Brunt et al., 2000; Zellner et al., 2006). This is consistent with findings from Racette et al. (2008) who reported that less than 30% of first year university students consume the recommended amount of FV and that university students are at risk of gaining weight more quickly than those of the same age not attending university (Holm-Denoma et al., 2008). As living away from home is a vulnerable

time for young people and a potential contributor to a less healthy diet and gain in weight, strategies for promoting healthy lifestyle behaviours in this population are important.

This research proposal aims to conduct an intervention using FB, a social network which is popular with young adults as it is reported that 89% of young adults aged 18-29 years, use social networks (Patrick et al., 2014). The global widespread of social networks sites and applications has been mostly credited to FB which, in 2013 achieved more than 1.11 billion active users (Patrick et al., 2014) demonstrating that this is a popular choice with students. Figures from USA indicate that students spend a minimum of 30 minutes each day engaging with Facebook (Patrick et al., 2014). As such networks are popular social networks sites and applications (e.g. FB) may therefore be useful as behaviours change tools and in altering social habits associated to weight gain and obesity for instance (unhealthy diet consumption) and might have a positive influence on weight management among young adults (Napolitano et al., 2013). Thus, interventions particularly those that use social networks sites and applications as a tool for addressing unhealthy eating behaviours, may be important in preventing obesity and helping young people adopt a healthy lifestyle. In designing the current RCT a systematic review of the literature (chapter 2) supported the use of FB as the choice of method to deliver nutrition education due to its popularity between young adults. In addition this was explored in the focus groups where students supported the use of FB as the most commonly used social network by students (chapter 3). Also, the recommendation raised from the focus group by students (chapter 3) supported the use of healthy diets that is easy to be prepared e.g. FV. Therefore a randomised control trial was designed using Facebook as a tool to increase FV intakes of university students. In addition the intervention choose to provide fruit and vegetables as strong evidence indicated that diets of young adults was generally low in FV (chapter 3) and provision of F&V would improve the nutritional intake and quality of the diet. To our knowledge, this is the first study in the UK using social networks to influence eating

habits of university students. The aims of the study were: 1) to deliver and evaluate a nutrition intervention aimed at increasing FV intakes of university students living away from home, 2) to investigate the impact of providing 5 portions of FV weekly on biomarkers of FV intakes of students living away from home and 3) to investigate whether FV consumption was further enhanced when FB was used to provide nutritional education.

Materials and methods

Study overview and ethics

This four-week randomised controlled-trial was conducted at Ulster University, Coleraine campus in Northern Ireland (Figure 4.1). The study took place between January and May 2018. The ethical approval was obtained from Ulster University Research Ethics Committee.

Subjects and recruitment

Participants aged ≥ 18 years were recruited from Ulster University Coleraine campus using circular e-mail and face-to-face interactions. Eligibility was assessed using a screening questionnaire which was provided in this recruitment e-mail using Survey Monkey. The screening questionnaire included questions on age, gender, ethnicity, and educational status, intake of FV and use of social networks. Participants who were eligible to take part received a participant information sheet before commencement of the study. Written informed consent was obtained from eligible participants prior to participation.

Participants were eligible for the study if they met the inclusion criteria which was as follows: full time students registered at Ulster University, aged 18 years or over, low habitual FV consumption of ≤ 2 portions/day, local and international students, living away from home at least three days each week, attending Coleraine Campus at least one day each week and Facebook users. Exclusion criteria was as follows: part-time students, students taking vitamin C or A supplements, or medications known to affect nutrient absorption at any point during the study, students with diabetes or pre-existing medical conditions, high consumers of FV > 5 portions/day, pregnant women or those planning a pregnancy and students with eating disorders as determined by the screening questionnaire.

Study protocol

Demographic information self-reported on the screening questionnaires was reviewed and assessed at initial appointment. All participants were allocated a unique ID number. Weight and height were measured using calibrated scales and a stadiometer respectively during the first visit. These were used to determine Body Mass Index (BMI) as weight in kg divided by height in meters squared (kg/m^2). Following pre-testing, participants were randomly allocated by a clinical manager using Minim randomisation software to one of three study groups: control group, or FV only group (*F&V group*) or FV group plus Facebook page (*F&V + FB group*).

F&V Group: The F&V group were provided with 5 portions of seasonal FV each day (3 portions vegetables, 2 portions fruit) for four weeks. Participants were given a choice of FV depending on individual preferences (determined at recruitment) using a list of seasonal fresh FV. A portion was considered as an 80g serving (e.g. one medium orange, one medium banana, one medium apple, 3 heaped tablespoons of peas, or 2 broccoli spears) as defined by the Food Standards Agency. Participants collected their FV twice weekly on Monday and Thursday which was arranged and prepared by the researcher. The FV portions were purchased and supplied by placing weekly internet supermarket (Tesco.com) orders. Participants were asked to return all uneaten FV and also waste in the cold bags twice weekly. This was assessed by the researcher and recorded. Participants were asked to record what they ate in four-day food diaries. The F&V group received no FB support or messages regarding nutrition education and received only FV.

F&V + FB group: Participants randomised to F&V + FB group received the same intervention as for the FV group (i.e. 5 portions fruit and vegetables daily for 4 weeks). In addition, they received intervention in the form of nutrition education messages via FB regarding FV to increase FV over the 4 week intervention period, including recipes (Appendix 4) and information on ways to include a minimum of 5 portions FV each day (Appendix 4). During

the intervention, participants in the F&V + FB group received nutritional advice posted on their FB page three times a week to increase FV intakes. These communications included recipes for eating a minimum of 5 portions of FV each day, FV tips, pictures and messages. Participants were instructed to keep the FB page as a private page and avoid sharing the posts with other FB friends. Participants were encouraged to interact with a post by ‘liking, commenting or sharing’. FB response from participants was used to analyse the level of engagement. Engagement was analysed as a continuous variable (total number of interactions with the post). Participant-level engagement was defined as the number of participant interactions stratified by interaction type (e.g., like). For example, a participant who liked a photo on the FB page was said to have “received” that post.

The engagement with the FB page was assessed by counting available FB markers (e.g. posting comments, “liking” posts and time to response to posts, observing ‘seen by’ and the general compliance with each type of posts response).

Control group: Participants randomised to the control group received no intervention (no nutritional education, no free supply of FV during the intervention period) and they were asked to maintain their normal diet. However, on completion of the study, this group had the choice to avail of nutrition education messages and information on FB.

The three groups were instructed to continue their habitual diet with the additional FV being the only change to their dietary intake. After the end of the 4-week intervention period and during the follow-up phase of 3 weeks, the F&V group received no FV and the F&V + FB group received only FB support and education. The control group had no intervention.

Food intake was assessed at baseline by asking all participants to complete a four-day food diary using home measures. Participants were given detailed guidance as to how to measure and record their food intake for four days. So as to achieve precision and accuracy,

encouragement was given to participants to record any food or drink that they had utilising home measures over the four days (including two weekdays and weekend days). The F&V and F&V + FB groups were asked to consume the allocated FV and record this clearly in addition to any additional FV eaten.

Compliance to FV intake was determined by analysis of vitamin C (vit C) and carotenoid levels taken from blood samples. The four-day food diaries were also used post-intervention. The F&V + FB group was monitored for compliance of engagement and was encouraged through messages on the FB page at the beginning of each week to remind the participants and response time collated. The F&V groups were reminded to pick up FV using FB page, email and SMS messages and the F&V + FB group were encouraged to report issues via FB.

Facebook page contents

The FB messages were designed to encourage, reinforce and provide additional information on ways to achieve consumption of 5 a day FV to ultimately increase and change behaviour. According to the recommendation of the students in (Chapter 3) messages were released at regular intervals, with a different type of messages were being sent (1 post on FB each 2 or 3 days over the 4 week study using a variety of approaches as listed above). This was frequent in order to engaging participants and reminding them to respond. The messages were adopted from credible nutritional and dietetics websites (e.g. British Dietetics Association, Change for life, SafeFood) with links to these websites for further information (the credible nutritional and dietetics websites was also order by students in Chapter 3). Websites and information used was reviewed by 3 members of the research team and were piloted on 2 participants not included in the study to test appropriateness. Information provided was in the form of brief messages which signposted users to credible websites for further information.

Dietary intake

Participants completed one semi quantitative four-day food diary (4DFD) using home measures to record all food and drinks consumed over the recording period of four weeks. Participants were asked to complete a food diary at the post-intervention period. The four-day food records were adapted from a similar previous study (Neville et al., 2015) which assessed participation and compliance with eating FV. Food diaries were analysed using Nutritics nutritional analysis software package which converts the information into quantitative data (Nutritics, 2018). Participants' age, gender, height, and weight were also entered into the software. The portions of FV were calculated from the weight of each meal in grams (e.g., 1 portion = 80 g). In order to confirm validity, nutritional data was entered by the same individual and was checked by the research teams.

Return FV bags

Participants using cold bags to keep all FV consumed over the recording period of four weeks. Participants were asked to return all fruit and vegetables not eaten and any waste not used twice weekly. This was returned to the researcher to assess participation and compliance with eating FV. FV portions returned in the cold bags were recorded and analysed and converted into quantitative data. The portions of FV were calculated from the waste. Reasons for returning the uneaten FV were recorded when possible.

Blood collection, processing and analysis

All enrolled participants were required to provide a blood sample for baseline measurement, another one at four weeks post-intervention, and a final sample three weeks after the follow-up consultation. Furthermore, participants were instructed to fast from 10 pm the evening before venesection.

Fasting blood samples were obtained from the antecubital vein using a 21-gauge butterfly needle, as previously described, and 15 ml EDTA-coated vacutainers (Greiner Bio-One GmbH, Kremsmunster, Austria) were used to store samples and stabilise vitamin C and carotenoid molecules. Briefly, blood samples were centrifuged at 4°C (15 minutes, 2,200 rpm to allow for separation of whole blood into its respective components). Following sample isolation and homogenisation, serum was allowed to clot for < 60 minutes, whilst plasma samples were immediately refrigerated until further downstream processing. Serum and plasma samples were pipetted into 0.5ml aliquots and stored at -80°C until later batch analysis by HPLC.

Total Vitamin C (ascorbic acid) concentration in participant samples was measured using liquid chromatography-tandem mass-spectrometry (using an API 4000; AB SCIEX; Chromsystems Instruments and Chemicals GmbH; MassChrom Vitamin C), whilst carotenoid, serum retinol, and α - and β -carotene, were measured using a reverse-phase HPLC with diode-array detection.

Statistical analysis

A variability data from similar study by (Woodside, 2013) was used to calculate the sample size. However, An *a priori* power calculation with a two-sided significance level of 5% and power at 80% resulted in primary endpoint for a total of 30 participants plus addition doubling the sample size for drop-out concluded that a total of 60 participants was required to observe a significant difference in the influence of FB and provision of fruits and vegetables on increasing FV intake and Vitamin C and Carotenoid mean difference (GPower version 3.1).

Incentive vouchers were given to enhance participants' compliance to measurements at the end of the study, in particular to reduce dropout for control (Wagner et al. 2016). All further statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics for Windows, version 21.0, IBM Corp, Armonk, NY) with significance set at $P < 0.05$ throughout. The Shapiro-Wilk test was used to determine if data followed a normal distribution and skewed variables were transformed using the logarithmic function to attain a normal distribution or use non-parametric test for further analysis such as chi-square test. An independent t -test was used to test for differences between variables at pre-test and post-test. A repeated-measures ANOVA test was used to determine mean differences in FV consumption from pre-test, post-test and follow-up for all participants at three different time points. In case of drop out, intention to treat method was used to compensate the missing value.

Results

General characteristics of study participants

A total of 60 participants ($n = 36$, 60% female; $n = 24$, 40% male; $n = 42$, 70% European, $n = 18$; 30% International completed validated questionnaires and provided a blood sample for plasma Vitamin C and serum carotenoid measurement at baseline. However, final drop out percentage occurred in control group ($n=4$, 20%) and fruit and vegetables group (F&V) ($n=6$, 30%) and Facebook and fruit and vegetables group (F&V + FB) ($n=6$, 30%). The overall drop out was ($n=16$, 27%) which resulted in final number ($n = 44$) of participants who completed final assessment (Figure 4.2). Table 4.1 shows the characteristics of study participants by study group at baseline, however, by study group gender differed significantly ($P=0.005$) (which might be corrected for future study by stratifying the participants of the study equally by gender), although there was not a significant different among ethnicity ($P=0.082$). At baseline, both intervention groups F&V, F&V + FB differed significantly to control group ($P=0.039$) with regards body mass index 27.6 (SD 4.2), 24.6 (SD 5.8), 24.1 (SD3.1) kg/m^2 , respectively. There was no significant difference in participants' age between the study groups. Only one participant was a current light smoker. However, at the end of the 4 weeks intervention period there was a significant difference in the CHO between groups which showed that both intervention groups means 125.8 (SD 89), 120.7 (SD 82), respectively, were higher compared to the control group 114 (SD 31) ($P = 0.031$). However, for protein and fat there were no significant difference between groups means ($P = 0.061$) ($P = 0.059$) respectively.

Table 4.2 shows mean daily consumption of FV within and between groups. The 4 day food diaries results show that the mean difference in the amount of FV intake at the end of the four-week period by ANOVA between groups showed that there was a significant difference ($P=<0.001$) and the post-hoc showed that the difference was in the intake of both intervention groups compared to the control group with mean difference of 2.2 (SD 1.2) F&V group, 2.2

(SD 1.5) F&V + FB group, and 0.1 (SD 0.5) control group . The 4 day food diaries results also show that participants within both interventions groups had significantly increased their intake of FV from baseline to the end of the four-week intervention period from 1.7 (SD 0.4), 1.6 (SD 0.5) FV portions/day to 3.8 (SD 1.1), 3.7 (SD 1.7) FV portions/day for F&V and F&V + FB groups respectively. There were greater increases within both interventions groups compared to the control group which did not show any significant increase from baseline to the end of the four-weeks intervention period.

. The results from return bags (uneaten F&V) show the mean difference in the amount of FV intake at the end of the four-week period analysed by independent t-test between groups which showed there was no significant difference ($P=0.373$) in the intake of both intervention groups with mean difference of 2.8 (SD 0.7) and 3.0 (SD 0.6) portions/day in the F&V and F&V+ FB groups, respectively. However, participants within both interventions groups had also significantly increased their intake of FV from baseline to the end of the four-week intervention period from 1.7 (SD 0.4), 1.6 (SD 0.5) FV portions/day to 4.6 (SD 0.6), 4.7 (SD 0.4) FV portions/day for F&V, F&V + FB group respectively. This return bags results showed the compliance change over time by mean to support the 4DFD results and indicate that some participants had almost success in reaching the recommended level of FV intake. Thus, the returns bags was an effective tool for measuring the compliance for the long term. However, mean FV intakes in both intervention groups remained greater than those reported at baseline level.

Table 4.3 shows mean daily consumption of dietary fibre, vitamin C, vitamin A and carotene between groups at end of the four week intervention period from the 4DFD. The mean of both F&V and F&V + FB groups were significantly higher than the control group with mean difference in dietary fibre 18.8 (SD 5.5), 20.3 (SD 6.4), 14.6 (SD 4.0) g/d and dietary vitamin C 94.9 (SD 49.7), 81.7 (SD 41.9), 60.4 (SD 31.4) mg/d, ($P.005$ and $P.037$ respectively; see

Table 4.3. However, there was no significant difference between groups with respect to reported dietary intakes of vitamin A and carotene.

Tables 4.4 Tables 4.4 shows compliance change over time by mean plasma vitamin (vit) C and serum retinol concentration across the three study groups. There was a significant difference between groups among vitamin C and Retinol level ($P.025$; $P.035$) respectively with adjusting for cofounders baseline time and BMI, mean plasma vit C for both intervention groups were higher than the control group at the end of the four-week intervention period, and showed a significant increased from baseline to the end of the four-week period within F&V and F&V + FB groups while no change occurred within the control group, 61.2 (SD 21.2), 57.6 (SD 20.4), 37.6 (SD 21.5) $\mu\text{mol/l}$ ($P0.022$, $P0.002$, $P0.975$ respectively; see Table 4.4) However, at the end of the follow up period, no significant increase or maintenance of the intake was found in any of the groups.

Similarly, serum retinol concentrations increased in both intervention groups compared to the control group over the four-week intervention period with a significant increase from baseline to the end of the four-week period for F&V and F&V + FB groups was observed while no change was seen in the control group, 1.8 (SD 0.5), 1.7 (SD 0.6), 1.4 (SD 0.2) $\mu\text{mol/l}$, ($P.046$, $P.042$, $P.708$ respectively; see Table 4.4). However again at the end of the follow-up period, either no significant increase or maintenance of the intake was found between or within any group.

Table 4.5 shows compliance change over time by mean serum α and β carotene concentration on daily consumption of FV within the study groups. There was significant difference between groups among α and β carotene level ($P.014$; $P.034$) respectively with adjusting for cofounders baseline time and BMI, however mean of α carotene for the F&V + FB group was higher than the control group at the end of the four-week intervention period. The mean of α carotene for the F&V group showed an increase from baseline to the end of the four-week period but was not

significant. No change occurred in the control group, 0.17 (SD 0.1), 0.15 (SD 0.2), 0.08 (SD 0.04) $\mu\text{mol/l}$, ($P=0.086$, $P=0.0012$, $P=0.585$ respectively; see Table 4.5). However, at the end of the follow up period (i.e. 3 weeks after the end of the intervention period), either no significant increase or maintain of the intake was found among all groups except for α and β carotene in F&V group which slightly maintain the level of intake.

The mean change in serum β carotene was found to be significantly higher for both intervention groups than the control group at the end of the four-week intervention period and showed a significant increased from baseline to the end of the four-week period for F&V and F&V + FB groups whilst no change happened in the control group, 1.7 (SD 1.1), 1.2 (SD 1.1), 0.7 (SD 0.5) $\mu\text{mol/l}$, ($P=0.032$, $P=0.037$, $P=0.909$ respectively; see Table 4.5). However, at the end of the follow up period either no significant increase or maintenance of the intake was found in any group.

Table 4.6

Engagement in FB were significantly difference between time ($P=0.003$). Of those 20 participants in the *F&V + FB group*, 95% engaged with FB regularly with 70% classified as highly active, 20% moderately active and 10% minimally active in the 4 weeks intervention period. While, in the follow up period of those 70% engaged 35% classified as highly active, 15% moderately active and 50% minimally active.

Discussion

This study aimed to deliver and evaluate a nutrition intervention aimed at increasing FV intakes of university students living away from home and to investigate the impact of providing five portions of FV weekly on biomarkers of FV intakes. Another aim was to investigate whether FV consumption was further enhanced when nutritional education was delivered through the social networking site FB.

Results show that providing five portions of FV each day for four weeks can help to increase FV consumption in university students from two portions to five portions for four weeks. However, providing additional nutrition education via FB was insufficient to change behaviour in relation to FV intake in the longer term (i.e. any change to FV consumption during the intervention period was not sustained at 3 weeks after the end of the intervention. These results are consistent with similar studies by Appleton (2013) who found that, although there was some reduction of change in FV consumption after the end of the four-week intervention, in this study mean FV intakes in both intervention groups remained higher than those reported at baseline in the F&V and F&V+ FB groups according to results from return bags after the end of the 4 weeks intervention period.

At the four-week intervention period, results according to food diaries showed that FV intakes were greater in both intervention groups compared to the control group, with the F&V and F&V + FB groups consuming on average two more portions of FV a day. Therefore, the highest effect on FV portions intake was in those who had been provided with free FV to increase their FV consumption as part of the intervention. Moreover, both intervention groups were successful in achieving the recommended level of FV intake with average increase of intake from baseline (mean increase of 4.6 (SD 0.6) and 4.7 (SD 0.4) portions/day in the F&V and F&V + FB groups, respectively).

The α - and β -carotene are the greatest rich carotenoids in FV and are mainly available in orange and yellow FV which indicate the reliability of the intake (Woodside et al., 2013). These foods were consumed commonly in the intervention groups in the current study. This is similar to the finding of an Australian study (Louis et al., 2007) and indicate that these foods would reflect an accurate amount of the intake of FV. A dose-response relationships between different food group intake and the levels of vitamin C and carotenoids in plasma has been proved by previous researchers in other large adults prospective cohort studies (Louis et al., 2007) offering a strong evidence for their use as reliable biomarkers of consumption and compliance. Different correlations between dietary carotenoid intake and plasma carotenoid level in the majority of previous studies (Woodside et al., 2013) have been stated, with correlations coefficient resulting from 0.2 to 0.7 and most studies showed statistical significance for at least one of the primary carotenoids measured. This suggests that these biomarkers can be used as reliable markers of FV intake and compliance. In addition to blood biomarker in this current study, the return cold bags were used for measuring the compliance which was successful as a tool in measuring FV intake and provided evidence on the consumption of FV in conjunction with 4 day food diaries. The returns bags showed different results than the (4DFD) which indicate that there was a misreporting by the participants in the (4DFD). However, the returns bags might be more reliable tool than the 4DFD in this study because the participants were return them twice a week over 4 weeks. The return bags results showed that level of FV intake weekly was not change (Napolitano et al, 2013) throughout the intervention period

This study shows positive results in terms of increasing FV consumption during the study period and by encouraging participants to continue to eat F&V after the study. Participants selected preferred fruit and vegetables to consume which may enhance compliance and encourage a change in behaviour. In some case participants enjoyed the opportunity to consume new F&V not previously tried

Engagement with FB showed similar results to previous studies in the decreasing level of participation over 4 weeks and the follow up period in FB (Napolitano et al, 2013) throughout the intervention period. This may have been associated with study fatigue or indeed pressures of the courses and the impact of exams and coursework deadlines as end of semester approached. However, the follow up period results of the engagement with post indicate that FB was not successful in changing behaviour in the long term.

This enhancement in FV consumption, in addition to engagement with the FB page at the 4-week period, may demonstrate a contribution to the research; the study design; and the approaches utilised in the delivery of the intervention. Participants did not face restriction in their selection of FV, and motivated to attempt different FV that they may not have consumed before the intervention.

FV were provided free-of-charge for participants throughout this intervention, therefore participants may have chosen to consume different or new varieties of FV which may have resulted in sustained increases in FV consumption. This is consistent with, previous studies which showed enhanced F&V intake when provided with different recipes and cooking methods and ideas of how to cook and include F&V in meals (Appleton, 2013; Lancaster, 2004). Furthermore, a finding of study which investigated barriers to increasing FV consumption in adults indicated that high FV intake was positively associated with more favouring of FV. The increased intake of FV by students at the end of the four-week period in both intervention groups might reflect the success of the methods used to support compliance. Apart from receiving a weekly delivery of FV, all participants received practical tips for three days a week via FB page regarding increased intake of FV and advice on preparation, storage and

incorporating FV into their habitual diet. They were encouraged to self-record their FV intake in the 4DFD during the intervention. The repeated exposure to nutritional advice via FB and a different types of FV might have lead the participants at the end of the intervention to find that FV easier to prepare, know how to store, consume and cook the FV and it was easier to select a different of FV when shopping. This might result in changing eating habits that they were able to sustain in the longer-term.

These findings are in agreement with another study carried out on adults who were low consumers of fruit whereby constant exposure to fruit for 5-week resulted in a significant increase in overall FV intake (Appleton, 2013).

The positive results of this current study may be as a result of provision of free F&V. Participants were students who lived on limited budgets and therefore enjoyed receiving the opportunity to try new varieties of F&V. However despite the fact there was no increase in the number of portions of FV intake at the end of the follow-up period which may have resulted from the fact that it was end of semester and May were focusing on studying for exams and associated stresses which distracted them from sustaining the increase in FV intake. Others were eating 5 portions each day at the end of the intervention and were not willing to eat more portions each day .At baseline, regardless of group allocation, participants were considered to be consuming <2 portions/day. However, the results showed that after the follow-up period, high level of participants were still consuming below the recommended level '5-a-day'.

In spite of that finding, numerous research has indicated that short-term improvements in FV intake are achievable in relation to a FV intervention (Fjeldsoe et al., 2011) It is regrettable that studies and researchers have returned for financial and logistical aspects to participants to review if beneficial alterations in FV consumption (driven by intervention) have been preserved at the one-year post-intervention. A recent systematic review that inspected the perseverance of behaviour alteration after dietary interventions identified that out of 157 trials

published since 2000; notably, 35% of them comprised a measure of preserving behaviour alteration (Fjeldsoe et al., 2011)

A number of related studies worth referring to have shown similar results to those in our study, in terms of increased FV consumption following participation in a FV intervention (Kristal et al., 2000; Stadler et al., 2010). Unlike our work, however, these studies were conducted in younger age groups (Nitzke et al., 2007; Papadaki, et al., 2008), with the majority also having short follow-up periods (Greene et al., 2008; Kristal et al., 2000). Encouragingly, a consistency with our research findings. It was found in these research that the intervention groups sustained increased intakes of FV post-intervention, in contrast to the control groups that did not receive these interventions. In these studies, the significance of alteration in FV intake (between control and intervention groups) was similar to that found in this current study. Such changes in FV intake may have clinical significance, given the diverse impacts on health and physiology that different nutrients and eating habits can engender (McCall et al., 2009).

Findings in this current study support those of other FV intervention studies which facilitate FV consumption while providing FB and FV in an intervention did not further enhance the intake (Hendrix et al., 2008). Moreover, our study which examined the changes in a four-week period of FV consumption in university students corresponds with most of the previous research conducted in younger population groups with low drop out and did not examine longer-term changes in FV consumption. However, it should be recalled that, unlike other research, the participants in this current study were recruited on the basis of existing low FV intakes in addition to being subject to circumstances specific to students living away from home. Therefore, the results of the current study may have differed from the general public who have free lifestyle and are already consuming larger amounts of FV.

A strength of our study was the high retention rate throughout the intervention period (four weeks) and using the intention to treat method (ITT) at the follow-up period. Another strength which is utilising of food bags to record uneaten F&V as a tool for measuring compliance of FV intake which was successful. A study limitation was the dependence on self-reported dietary consumption. While the 4DFD is a well-validated tool, the method is acknowledged as being prone to measurement error which may have resulted in under or over-reporting of FV intake (Black, 2000). However, this issue was minimised and overcome by measuring micronutrient status as a biomarker of intake and compliance in blood samples together with dietary intake at the beginning and end of the intervention. It is also possible that the methods used to select participants may have introduced potential recruitment bias in terms of self-reported daily intake of FV. Another limitation of the current study was the duration of the intervention period and follow-up period which may have shown only small variation in intakes of FV. Finally, our research was conducted in a university setting with low FV consumers and therefore our findings might not be generalizable to public or other groups.

Conclusions

This current study demonstrated that the provision of 5 portions of F&V free-of-charge increased consumption in a population of students who had habitually low intake within 4 weeks. However, FB was not effective at increasing intakes of F&V by providing nutritional education. Therefore, provision of free fruit and vegetables increased F&V consumption in university students in the short term but was ineffective in changing behaviour to eat healthily in the longer term. This study supports the use of online technology in providing education to enhance consumption of F&V by providing tips, however, in this study it was not effective at increasing intake. These outcomes might support and guide future interventions intended at changing dietary habits and must be considered when placing strategies to increase FV consumption at a population level.

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Figure 4.1

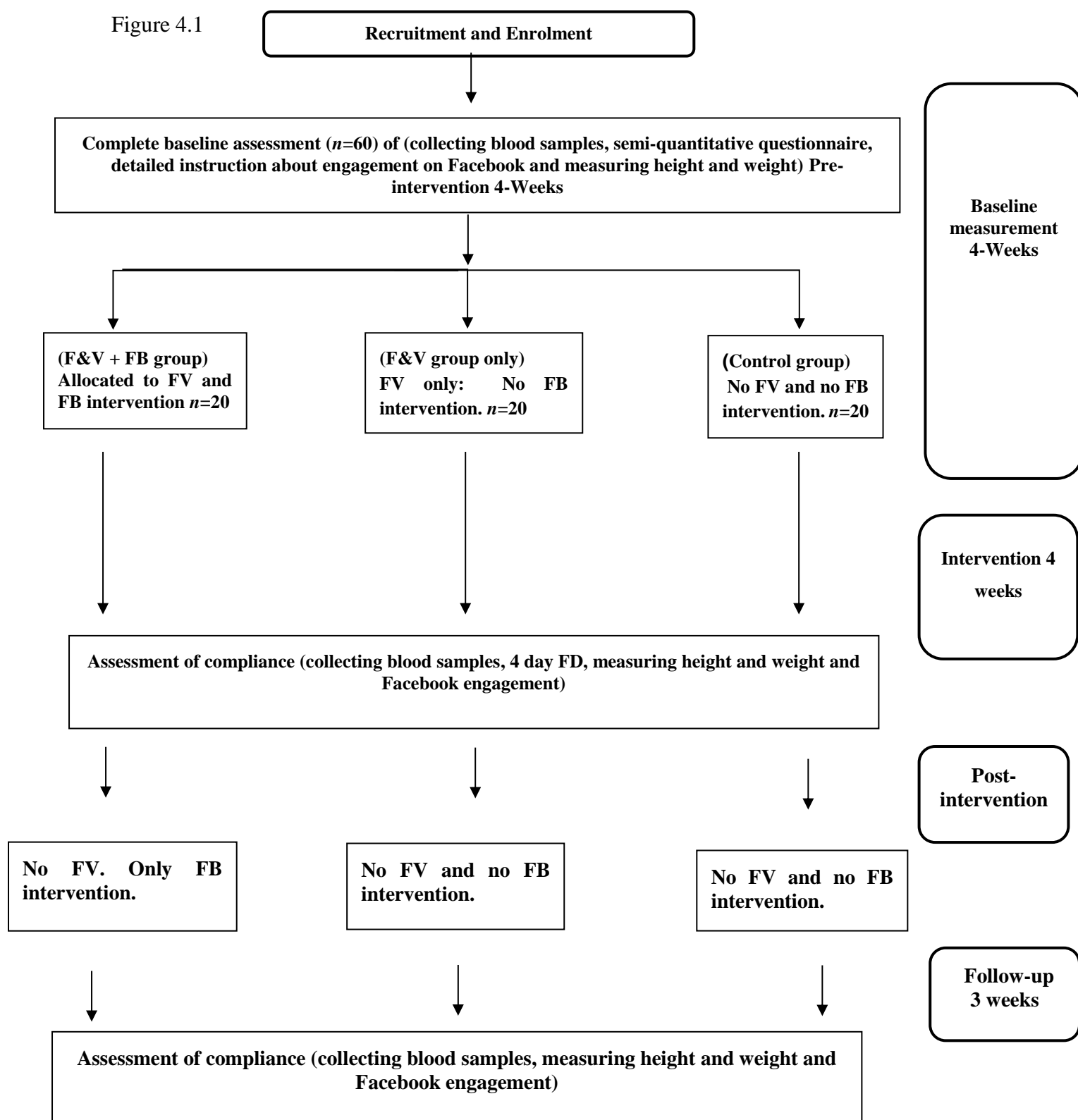


Figure 1 flow diagram. Participants were assessed for eligibility and have the baseline measurements taken in the first 4 weeks. Participants (n=60) were randomised to control group (n=20) or fruit and vegetables group only (F&V) (n=20) or Facebook and fruit and vegetables group (F&V + FB) (n=20). Then at follow-up the control group continued to receive nothing, the fruit and vegetables group (F&V) received nothing as well, while the Facebook and fruit and vegetables group (F&V + FB) received only Facebook support. **No=** means 'did not receive'; FD= 4 day food diaries

Figure 4.2

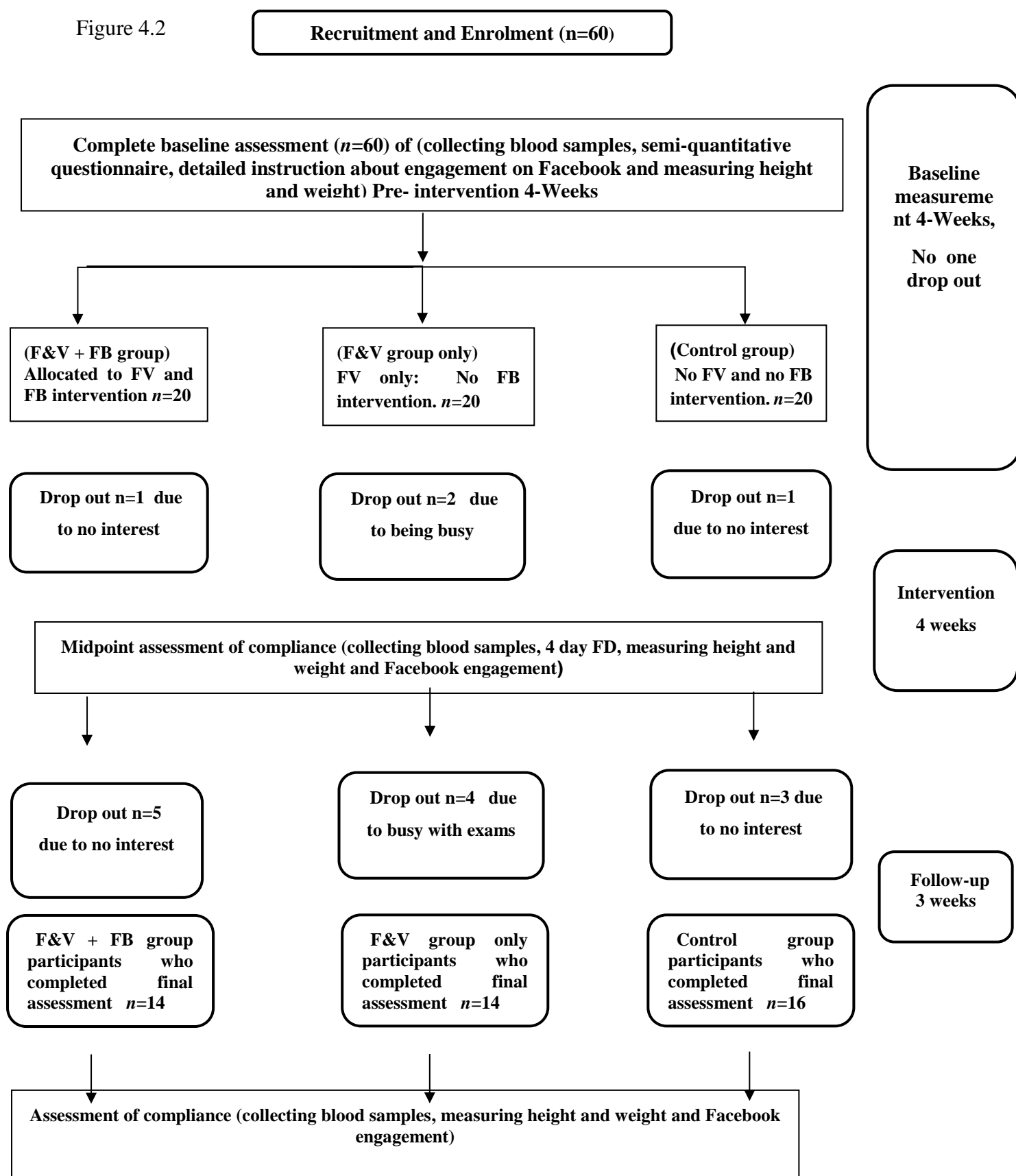


Figure 4.2 consort drop out flow diagram. Final drop out percentage in control group (n=4) (20%) and fruit and vegetables group only (F&V) (n=6) (30%) and Facebook and fruit and vegetables group (F&V + FB) (n=6) (30%). The overall drop out is (n=16) (27%)

Table 4.1. Characteristics of study participants (n=60) by study group at baseline.

Variables	Control group (n=20)	F&V group (n=20)	F&V + FB group (n=20)	<i>P</i>
Gender				
Male	65%	35%	40%	0.005^a
Female	35%	65%	60%	
Ethnicity				
UK	45%	75%	75%	0.082 ^a
European	5%	10%	0%	
International	50%	15%	25%	
Age (Years)	24.9 (3.2)	23.6 (3.8)	24.7 (4.1)	0.489 ^b
BMI (kg/m²)	27.6 (4.2)	24.6 (5.8)	24.1 (3.1)	0.039^b
TEI (Kcal/d)	1296 (257)	1409 (309)	1540 (323)	0.041^c
CHO (g)	114.8 (31)	125.8 (89)	120.7 (82)	0.031^c
CHO (%)	49 (4.7)	52 (5.7)	51 (5.7)	0.022^c
Protein (g)	38.7 (18)	40.7 (24)	41.7 (19)	0.061 ^c
Protein (%)	18.5 (2.7)	19.5 (2.7)	20.5 (2.7)	0.093 ^c
FAT (g)	52 (15)	48.1 (20)	50.1 (211)	0.059 ^c
FAT (%)	32 (5.7)	30 (4.6)	29 (4.2)	0.060 ^c

F&V, Fruit and vegetables; TEI, total energy intake; Values are mean (SD) for all variables. ^a Difference in group percentage and P value determined using chi-square; ^b Difference in mean age and BMI at baseline; ^c Difference in mean at the end of 4 weeks intervention period compared across groups using one way ANOVA.

Table 4. 2. Mean daily consumption of fruit and vegetables within and between groups.

	Daily portions of F&V			Daily portions of F&V	% achieving 5 a day	
Groups	Pre-intervention (baseline)	Post-intervention (4 weeks)	<i>P</i>	Δ F&V ^b		<i>P</i>
¹ Food-diary						
Control group (n=20)	1.5 (0.5)	1.6 (0.4)	0.287 ^a	0.1 (0.5)	0	<.0001 ^b
F&V group (n=20)	1.7 (0.4)	3.8 (1.1)	<.0001 ^a	2.2 (1.2)	40	
F&V + FB group (n=20)	1.6 (0.5)	3.7 (1.7)	<.0001 ^a	2.2 (1.5)	30	
² Return bags						
Control group (n=20)	NA	NA		NA		0.373 ^b
F&V group (n=20)	1.7 (0.4)	4.6 (0.6)	<.0001 ^a	2.8 (0.7)	60	
F&V + FB group (n=20)	1.6 (0.5)	4.7 (0.4)	<.0001 ^a	3.0 (0.6)	40	

F&V, Fruit and vegetables; Δ F&V, Post minus Pre intake; NA, not applicable. Values are mean (SD) for F&V portions reported from ¹food-diary or ²return bags. ^aPre versus post intervention intake compared using paired Sample t-test. ^bChange in F&V intake compared across groups using ANOVA. ^cChange in F&V intake compared across groups using an independent t-test

Table 4. 3. Mean daily consumption of dietary fibre, vitamin C, vitamin A and carotene between groups at end of 4 week intervention period.

Micronutrients¹	Control group (n=20)	F&V group (n=20)	F&V + FB group (n=20)	P^a
Fibre (g/d)	14.6 (4.0)	18.8 (5.5)	20.3 (6.4)	0.005
Vitamin C (mg/d)	60.4 (31.4)	94.9 (49.7)	81.7 (41.9)	0.037
Vitamin A (ug RE/d)	1854 (1526.7)	2160 (1435.4)	2476 (2195.9)	0.536
Carotene (ug RE)	7910 (7051.4)	9031 (6264.76)	10898 (9936.5)	0.487

F&V, Fruit and Vegetables; RE, retinol equivalents. Values are mean (SD) for micronutrients reported from ¹food-diary. ^aChange in micronutrients intake compared across groups using One Way ANOVA.

Table 4.4 Effect of intervention on mean plasma Vitamin C (umol/l) and serum Retinol (umol/l) concentrations across three different time period by study group

	Mean Vitamin C and Retinol level			
Groups	Pre- intervention (Baseline)	Post- intervention (4 weeks)	Follow-up (3 weeks)	P
Vitamin C (umol/l)				
Control group (n=20)	37.3 (17.1)	37.6 (21.5)	35.9 (25.7)	0.975 ^a
F&V group (n=20)	49.0 (17.7)	61.2 (21.2)	53.1 (22.9)	0.022^a
F&V + FB group(n=20)	43.8 (17.0)	57.6 (20.4)	56.4 (46.5)	0.002^a
Retinol (umol/l)				
Control group (n=20)	1.7 (0.4)	1.4 (0.2)	1.6 (0.2)	0.708 ^b
F&V group (n=20)	1.6 (0.4)	1.8 (0.5)	1.5 (0.2)	0.046^b
F&V + FB group(n=20)	1.5 (0.6)	1.7 (0.6)	1.5 (0.5)	0.024^b

F&V, Fruit and Vegetables; RE, retinol equivalents. Values are mean (SD) for micronutrients reported from blood samples. ^{a,b}Change in micronutrients intake compared across groups using a Repeated measure ANOVA. **There was a significant difference between groups among vitamin C and Retinol level ($P.025$; $P.035$) respectively.**

Table 4.5. Effect of intervention on mean serum α and β carotene (umol/l) concentrations across three different time period by study group

	Mean α and β carotene level			
Groups	Pre-intervention (Baseline)	Post- intervention (4 weeks)	Follow-up (3 weeks)	<i>P</i>
α carotene (umol/l)				
Control group (n=20)	0.07 (0.05)	0.08 (0.04)	0.07 (0.06)	0.585 ^a
F&V group (n=20)	0.12 (0.12)	0.17 (0.1)	0.16 (0.1)	0.086 ^a
F&V + FB group (n=20)	0.07 (0.04)	0.15 (0.2)	0.08 (0.5)	0.012 ^a
β carotene (umol/l)				
Control group (n=20)	0.7 (0.7)	0.7 (0.5)	0.7 (1.1)	0.909 ^b
F&V group (n=20)	1.0 (0.8)	1.7 (1.1)	1.5 (1.2)	0.032 ^b
F&V + FB group (n=20)	0.7 (0.5)	1.2 (1.1)	0.7 (0.6)	0.037 ^b

F&V, Fruit and Vegetables. Values are mean (SD) for micronutrients reported from Blood samples.

^{a,b}Change in micronutrients intake compared across groups using Repeated measure ANOVA. **There was a significant difference between groups among α and β carotene level ($P.014$; $P.034$) respectively**

Table 4.6: Participants' engagement in FB posts by categories over 2 periods

	Engagement categories			P value
	Highly active	Moderately active	Minimally active	
Periods				
4 weeks intervention	70%	20%	10%	0.003
Follow up	35%	15%	50%	

Change in participants' engagement in FB posts compared across groups using Chi-square. Highly active =2-3 or more engagement in a week with post, Moderately active = 1 engagement in a week, Minimally active = 1 engagement in a month.

Chapter 5

**Dietary pattern of children at six years of age and associations with
nutrient intakes and obesity**

Abstract

Background

The incidence of childhood obesity is rapidly increasing worldwide (WHO, 2012) and is now recognized as a serious public health challenge in the 21st century in both low and middle income countries. Dietary pattern analysis arose within nutrition research, analysing diet as dietary patterns technique might assist interpretation for the complex nature of food consumption which may not be completely established during nutrient intake analysis.

Objectives

The aims of this study were 1. to identify dietary patterns in diets of Children using PCA method, 2. to investigate the relationship between dietary patterns identified and children's anthropometry/BMI Z scores, 3. to investigate the relationship between dietary pattern and nutrient intakes.

Methods

Subjects were 6 year old offspring of mothers who participated in Belfast cohort of HAPO study. Diet was assessed using 4-day food diary which was analysed using Nutritics nutritional analysis software and a food frequency questionnaire to identify frequencies of consumption of 44 foods item with which 566 children consumed 44 foods/food groups at 6 years of age. BMI was calculated using LMS growth to convert the weight, height and BMI data of each individual child into height-for-age, weight-for-age, and the BMI-for-age z-scores. Children were classified using BMI z score < -2 SD are categorized as underweight while those who reach $-2 - 0.999$ are categorized normal weight and those children who are BMI $+1SD - < +2SD$ are categorized as overweight and $\geq +2$ SD are considered as obese.

Results

Three dietary components loaded were identified. The first dietary pattern identified was given the label 'processed diet'. The second dietary pattern identified was given the label 'junk diet' and the third dietary pattern identified was given the label healthy 'diet'. Significant positive correlations were observed between scores for dietary pattern 2 'junk' and weight z scores ($r.111$; $p<.021$), BMI z scores ($r.099$; $p.017$), and waist to height ratio ($r.098$; $P.018$), hip circumference ($r.131$; $P<.031$) and mid arm ($r.141$; $P<.011$). Significant positive correlation was also observed between scores for dietary pattern 3 'healthy' and height z scores ($r.092$; $P.026$). However, no significant relationships were found between scores for 'processed diet' and dietary patterns and children's anthropometry.

Conclusion

These findings suggest that children who consumed high sweets and sugary diet at 6 years of age may be at increased nutritional risk for obesity and may experience more health complications related to obesity into adulthood.

Introduction

Obesity is increasingly recognised a major socio-economic health burden, as it is negatively associated with diverse pathophysiological states (it is a common co-morbidity), such as various cancers, metabolic syndrome and chronic inflammation. Remarkably, non-communicable diseases such as obesity, cancer, type 2 diabetes, and diverse auto-immune/inflammatory states now outnumber infectious diseases as the leading causes of human mortality globally (Boutayeb and Boutayeb, 2005), and worryingly, the incidence of childhood obesity is rapidly increasing worldwide (WHO, 2012).

Obesity can be a particular challenge in low- to middle-income families and environments, where education and disposable income levels dictate access to health food options (Ogden et al., 2017). Therefore, educational efforts to underpin health understanding in the public should remain a focus of public health policy globally, as it has been across the developed world for the past two decades (Dietz, 1999).

Although estimates vary, research in a large cohort by Weng et al 2012 and colleagues indicates that around 23% of children aged between 4-5 years are obese, demonstrating and representative of the profound prevalence in developed economies. The same work also showed that 33% of 10-11 year-olds are obese or overweight (Weng et al., 2012), illustrating how the obesity trend continues during childhood.

As mentioned, childhood obesity has a direct and long-term impacts on health and well-being (Daniels, 2009; Reilly and Kelly; 2011), and several studies have shown that if an individual is obese as a child, it is more likely to be obese as an adult (Eastwood, 2013; Weng et al; 2012). In fact, evidence suggests that a child's weight at 5 years of age is a good indicator of the future health of a child (Pot et al, 2012), and the increasing numbers of children with metabolic dysfunctions, such as diabetes and dyslipidaemias, are testament to the fact that modern

western diets are deleteriously associated with good health outcomes (Biro and Wein, 2010; Cole et al, 2000; Han et al, 2010).

The molecular mechanisms associated with the obese physiological state are diverse (as large adipose tissue depots alter hormonal regulation of metabolism, not to the mention that blood lipids are major regulators of different metabolic pathways (Standring, 2008) and not fully understood, although exciting research is illustrating, that it happens when energy consumption become more than energy expenditure which results in the fat accumulation in the body (Racette et al, 2003)

The causes of obesity are multifactorial and difficult to abrogate at the population level, with genetic, environmental and stochastic factors coalescing to underpin the state (Cummings and Schwartz, 2003). Lifestyle factors – such as socio-economic status, physical activity levels, diet, and alcohol consumption – are of particular importance to regulating an individual's predisposition to becoming obese (Crawford et al, 2001; Watts et al, 2004; Wieting, 2008).

Evidence suggests that genetic factors contribute to a child's susceptibility to obesity (Fischer et al., 2009; Speakman, 2013), with weight gain early childhood (0-5 years of age) being a particularly strong predictor of future obesity and metabolic risk (Gardner et al, 2009); demonstrative of the high-penetrance of certain genetic variants. Likewise, adulthood obesity developing risk was higher in case one of the parents of an obese child at least, was obese as well (Whitaker et al, 1997).

It is clear from the peer-reviewed science that high energy (caloric) intake will lead to obesity development (Bradle et al, 2010), and to make matters worse, many children in United Kingdom and Ireland do not reach the recommendation level of portions vegetables and fruit; which contribute essential amino acids, fibres, vitamins, minerals and other macronutrients essential for good health and normal metabolism. In fact, one-in-five of the main sources of

energy in childhood diets were found to come from biscuits, chocolates, confectionary and high-sugar drinks (Safefood, 2013), illustrating how junk food contributes to the obesity epidemic. Although the importance of education has already been alluded to, reports in the literature suggest that children in the UK consume low nutritional quality (and energy-dense) fast foods both at school and at home (Wood and Harper, 2008). Unsurprisingly, perhaps, given their role-model status, evidence suggest that parents have an important role which impact on their children's eating patterns, habits and behaviours (Savage et al, 2007). Indeed, it has been shown that a mother's BMI is associated with the BMI of the child, even if eating behaviours and food attitudes vary between individuals within a family. (Laessle et al, 2007) Healthy eating in children and young adults is particularly vital behaviours that established early in life and likely to last for adulthood and important for cognitive development and growth (Lobstein et al, 2004). Such dietary behaviours have immediate effects on weight gain and health and eventually lead to poor eating behaviours into adulthood.

Thus, it can be appreciated that obesity is a combination of various risk factors, with behaviour and lifestyle modifications being powerful interventions to avoid the development of this pathophysiological state. Indeed, although many studies have analyse the relationships between the nutrient intake of an individual and development of disease or adverse health outcomes (Willet, 1998), nutrients are seldom consumed individually in foods, but rather are commonly consumed in combination with other nutrients as part of balanced meals.

Therefore, researchers today are increasingly investigating the association between dietary patterns (the way people treat and interact with food, including their choices of nutrients, over established periods of time) and behaviours and health outcomes within study populations (Gibson, 2005 and Newby and Tucker, 2004). Indeed, insightful studies suggest that analysing diet as dietary patterns technique might assist interpretation for the complex nature of food

consumption, which may or may not be fully established during specific-nutrient intake analysis (Newby and Tucker, 2004).

Dietary pattern analysis arose within nutrition research (Newby and Tucker, 2004). There are two methods for defining dietary patterns:

1. Theoretical patterns, food intakes are jointly classified by applying particular standards, usually on the basis of national guideline/recommendations for food intake. Usually, such eating patterns take the form of a dietary index such as the following: the Healthy Eating Index (HEI; Kennedy et al., 1995), the Diet Quality Index-International (DQI-I; Kim et al., 2003). As well as the Diet Quality Index for Pregnancy (DQI-P; Bodnar & Siega-Riz, 2002)
2. Empirically-derived patterns, dietary patterns are acquired by means of data reduction statistical methods like principal component analysis and cluster analysis. These utilised the strength of inter-correlations between dietary variables in order to condense the data into smaller groups of clusters and components (Pallant, 2007).

Studies suggest that analysing diet as dietary patterns technique might assist interpretation for the complex nature of food consumption, which may or may not be fully established during specific-nutrient intake analysis (Newby and Tucker, 2004). Dietary patterns have been identified in adults, however more recently a similar study in UK has investigated dietary patterns in children of similar age in relation to obesity factors and nutrient intakes (Northstone and Emmett, 2015). Therefore, the aims of this study are:

1. To identify dietary patterns in diets of Children using PCA method.
2. To investigate the relationship between dietary patterns identified and children's anthropometry/BMI Z scores.
3. To investigate the relationship between dietary pattern and nutrient intakes.

Study protocol

Study design

This study comprises the finding of retrospective exploratory principal component analysis (PCA) of nutritional data gathered as part of a nutritional study of HAPO, Belfast follow up cohort. The nutritional data was collected using a validated 4-day food diary and food frequency questionnaire (FFQ) which assessed the frequency with which 566 children consumed 44 foods/food groups at 6 years of age. Data on the children's anthropometry are included in statistical analysis in this chapter.

Background to the HAPO study

This study was based on participants in the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study. This was a prospective observational study examining maternal glycaemia and pregnancy outcomes. The objective of this study was to explain the risk of adverse pregnancy outcome related with degrees of maternal glucose intolerance less-severe-than overt diabetes mellitus during pregnancy. The study collected high quality standardised data between July 2000 and April 2006 on 24,000 women from 15 centres across 9 countries worldwide. One of these centres was Belfast.

Subjects

This study involved 1639 mothers who participated in Belfast cohort study. In order to be eligible, women were required to be over the age of 18 and to be recruited prior to 31 weeks' gestation. All pregnant women were eligible except for those with at least one of the following exclusion criteria: planned delivery at a non-field centre hospital, aged under 18 years, unable to complete the (OGTT) within 32 weeks' gestation, date of most recent menstrual period (LMP) uncertain and no available ultrasound (US) estimation from six to twenty-four weeks of gestational age, conception using gonadotropin ovulation induction or by in vitro

fertilisation, multiple pregnancy, glucose testing before recruitment or a diagnosis of diabetes during or antedating pregnancy requiring treatment with medication, known to be HIV positive or to have hepatitis B or C, participation in another study which might interfere with HAPO, previous participation in HAPO, or inability to converse in the languages used in field centre forms without the services of an interpreter. With regard to the women who declined to participate, educational level and age were confirmed. Mother-child pairs were invited to participate in additional analysis at six years post-natal, with 1,373 accepting that offer

Ethical approval

This PhD study has been reviewed and received ethical approval from the School of Biomedical Sciences Ethics Filter Committee at Ulster University. Approval reference number: FCBMS-14-030. Each participant gave informed consent prior to commencing the study and had a unique identification number that was used throughout the study to provide anonymity to both the mother and child.

Offspring BMI

Weight for age z scores; length for age z scores; percent body fat; individual skin-folds were used in this study when children had anthropometric measurements recorded shortly after birth (72 hours) - allowing for the monitoring of changes in growth in the offspring.

Those offspring with z scores between -1 and 0.999 were considered to display normal growth patterns, whilst those who had values +1 SD to $< +2$ SD away were categorised as overweight. Those individuals $\geq +2$ SD away were considered obese, as previously described (Pan and Cole, 2012).

The LMS Growth Microsoft Excel add-in software was used to record the weights and heights of children at 6 years of age (Pan and Cole, 2012). This software was specifically designed to analyse an individual's weight, height and BMI according to height-for-age, weight-for-age,

and the BMI-for-age z-scores. Thus, this software is able calculate BMI z scores using deposited data, such as 1990 growth charts from the UK. The raw data (physical measures taken from children) were entered onto the Excel spreadsheet and converted into z scores - calculated from the LMS curves, which serve as reference centile curves.

The median (M), coefficient of variation (S), and skewness (L) of the data show how the distribution of a measurement changes with participant age. Those children with BMI z scores < -2 SD were categorised as being underweight, while those who reached values between -2 and 0.999 were deemed to be of normal weight. Those children who had BMI $+1$ SD to $< +2$ SD were categorised as overweight, and when BMI $\geq +2$ SD, participants were considered obese (Pan and Cole, 2012).

Nutritional analysis

Offspring's Dietary Intake

Dietary data was available from 1023 of the children that presented for follow-up at 6 years. This was in the form of 4-day food diaries, based on 2-week days and a weekend.

Mothers completed these FDs on behalf of their children, and were instructed to account for the intake of all food and beverages consumed during that time. Furthermore, Mothers were requested to record detailed information relating to the quantity and types of foods and drinks consumed within the research period. They were also asked to classify each eating or drinking event (e.g. morning snack, lunch, tea) and to record information relating to brand names of food consumed, cooking methods, and any recipes used. The food diary was completed at home and posted back to the research centre upon completion.

Nutritional Analysis

The information collected from the 4-day FDs was qualitative in nature, as household measures (e.g. cups, spoonful, bowl etc.) and rough estimates (e.g. “small plate”) were used to describe portion sizes. In order to convert this qualitative data into quantitative data, diaries entries were transcribed into Nutritics (v 3.06) nutrient analysis software.

Nutritics includes nutrient information for over 125,000 foods, with data being compiled from various sources, such as McCance and Widdowson 7th edition, 2015 (Roe et al., 2015) and the USDA National Nutrient Database for Standard Reference - Version 28 (USDA, 2016). A standard coding procedure was used to ensure consistency of entry into Nutritics.

The Nutrition and Diet Resources guide; *“What is enough, a guide to age appropriate food size portions”* (NDR, 2013) was used to quantify age- and gender-appropriate portion sizes.

The output generated from Nutritics gave information regarding total energy intake (EI) in the form of kilocalories (kcal) and megajoules (MJ), as well as information on protein carbohydrate and fat content as a percentage of EI.

The quantitative output data was entered into the software programme SPSS (V.22, IBM) for subsequent statistical analysis.

Sub-sample analysis has been completed on 566 study participants, and this data will be used to investigate the association between maternal and child nutritional intake at 6 years of age. This was then used to calculate nutrition quality scores, and to assess how often children consumed each type of food, from the following options: never; once per month; once per week; two to four times per week; five to seven times per week; two to three times per day; four or more times per day.

The value ‘1’ was given for ‘never or less than once a month’, whilst ‘9’ was reserved for ‘6+ times per day’. Children missing values for each food or food group were coded as missing,

and finally, anthropometric and background lifestyle data collected as part of the follow-up study, were used in conjunction with quantifiable nutritional data for statistical analysis.

Principal Component Analysis

Principal Component Analysis (PCA) is an established method of data reduction that condenses data into smaller groups of components according to the strength of the inter-relationships dependence between variables (Pallant, 2007). Two main methods of PCA identified within the literature are: exploratory PCA and confirmatory PCA (Tabachnick and Fidell, 2007).

Exploratory PCA is generally utilised during the initial stage of a research. This helps with exploring the inter-correlation between a groups of variables. In the other hand, confirmatory PCA is usually conducted in the latter phases of research to verify a previously-defined hypothesis (Tabachnick and Fidell, 2007). The method used in this study is the exploratory PCA, which was used to identify dietary patterns in children enrolled into the HAPO Belfast cohort.

Preparation of Food Frequency dataset

The validated FFQ gathered data regarding the frequency of 44 food items were consumed, with 6 options provided for a response: never/rarely; once in two weeks; 1-3 times/week; 4-6 times/week; daily; more than once per day. Quantitative values were required for each response to conduct the PCA. Consequently, to translate response choices into quantities of portions consumed weekly, the quantitative values below were used: 0 for never/rarely; 0.5 for 1-3 per month; 1 for once in a week; 3 for 2-4 times/week; 5.5 for 5-6 times/week; 7 for once a day; 14 for 2-3 times daily; 28 for 4-5 times daily; 42 for more than 6 times a day.

Assessing appropriateness of FFQ data for PCA

The Kaiser Meyer Olkin (KMO) assessment of sampling adequacy test (Kaiser, 1970 & Kaiser, 1974) and Bartlett's Sphericity test (Bartlett, 1954) were conducted in order to investigate

whether the FFQ data were appropriate for data reduction regarding PCA. Tabachnick and Fidell (2007) suggest that the KMO analysis results must be greater than 0.6 and that Bartlett's Sphericity test must have a significant value of <0.05 prior to continuing with data reduction methods. A considerable variety of methods exists within exploratory PCA which may be utilised to extract the components which clarify most of the differences in the data (Pallant, 2007). The literature refers to a frequently applied method known as Catell's scree plot test in which a scree plot of eigenvalues for each components produced in PCA is plotted and subsequently reviewed in order to determine the point where the curve changes its direction (Catell, 1966). Catell implies that every components above this break must be retained because such components clarify most of the differences within the dataset (Catell, 1966). A factor loading of ≥ 0.3 for a variable implies a high loading for that particular food item (Pallant, 2007).

Statistical analysis

All statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics for Windows, version 21.0, IBM Corp, Armonk, NY) with significance set at $P < 0.05$ throughout. The Shapiro-Wilk test was used to determine if data followed a normal distribution and skewed variables were transformed using the logarithmic function to attain a normal distribution or use non-parametric test for further analysis such as chi-square test. An independent t -test was used to test for differences between variables. A one way ANOVA test was used to determine mean differences in dietary patterns. Simple, Partial, and multiple Correlations between certain nutrients were determined using Spearman's correlation and adjusting for confounders e.g. age, sex, mothers education, mothers BMI, energy intake.

Results

General characteristics of study participants

The mean, standard deviation, range (continuous) and frequencies (categorical) of general characteristics of study participants are available in table 5.1. presents the children's anthropometric characteristics and shows that for the total group (n=1317), there was no significant difference between male and female participants except in the case of waist circumference ($P=0.019$) and hip circumference ($P=0.013$) and height and BMI z scores. Males had significantly greater waist and hip circumferences than females.

Appropriateness of data for principal component analysis and exploratory PCA

The outcomes of KMO measure of sampling adequacy analysis with value of 0.795 and Bartlett's test of sphericity chi-square = 8692.23; $P<0.001$ indicate that the FFQ data were appropriate. Therefore, this study proceeded with exploratory PCA. The outcomes of initial exploratory principal component analysis identified 17 dietary components with eigenvalues above 1.0. In order to assess which of the 17 components identified, a scree plot of eigenvalues was plotted (figure 5.1) and the three components above the break in the plot were selected as those that explain the majority of variance within the plot.

Dietary patterns identified

Three dietary components loaded were identified, with 19.97% of overall variability being explained by the three dietary patterns (component 1- 7.78%, component 2- 6.46%, component and 3- 5.81%). The first dietary pattern identified had high positive loadings for beef, fish, pizza, peanut, chips, ice cream, potatoes, eggs, cakes/bun, bacon, pork, rice, pasta and fizzy drinks. Loadings ranged from 0.30 for crackers to 0.62 for fish fingers and therefore was given the label 'Processed dietary pattern' in order to aid interpretation. The second dietary pattern identified had high positive loadings for chocolate, crisps, sweets, yoghurt, cereal, bread, fruit

squash, biscuits, cheese, and butter with loadings ranging from 0.34 for low fruit squash to 0.73 for chocolate and was given the label 'junk dietary pattern'. The third dietary pattern had high positive loadings for fruit and vegetables, eggs, fish, brown rice, wholemeal bread and pasta, fish oil, porridge and cheddar cheese with loadings ranging from 0.30 for porridge to 0.64 for other vegetables and was given the label 'healthy dietary pattern'. All results are shown in table 5.2.

Dietary patterns and nutrient intakes

(i) Dietary pattern 1 ('processed')

Significant negative correlations were observed between scores for dietary pattern 1 and intakes of sugar ($r = -.130$; $P = .005$), sugars ($r = -.121$; $P < .001$), vitamin C ($r = -.098$; $P = .033$) and vitamin B ($r = -.109$; $P = .018$) (table 5.3).

(ii) Dietary pattern 2 ('junk')

Significant positive correlations were observed between scores for dietary pattern 2 'confectionary' and intakes of energy (Kcal) ($r = .113$; $P < .001$) carbohydrate ($r = .142$; $P = .002$), sugars ($r = .115$; $P < .001$), free sugars ($r = .153$; $P < .001$) table 5.3.

(iii) Dietary pattern 3 ('Healthy')

Significant positive correlations were observed between score for dietary pattern 3 and protein ($r = .241$; $P < .001$), carbohydrate ($r = .142$; $P < .001$), fibre ($r = .270$; $P < .001$), NSP ($r = .230$; $P < .001$), calcium ($r = .200$; $P < .001$) and retinol ($r = .130$; $P < .001$), vitamin C ($r = .294$; $P < .001$), vitamin D ($r = .152$; $P < .001$), carotene ($r = .262$; $P < .001$), thiamine ($r = .125$; $P < .001$), vitamin D ($r = .248$; $P < .001$), vitamin B6 ($r = .114$; $P < .001$), vitamin B12 ($r = .218$; $P < .001$), riboflavin ($r = .084$; $P = .004$) and vitamin K ($r = .213$; $P = .005$) table 5.3.

Children's anthropometry and dietary patterns

Partial correlation analysis was performed between scores for each of the three dietary patterns and measures of children's anthropometry (weight z scores, height z scores, BMI z scores, waist to height ratio, skinfold thickness at three sites (triceps (mm) and subscapular (mm)). Partial correlations were adjusted for age, gender and children BMI at 6 years of age. Significant positive correlations were observed between scores for dietary pattern 2 'Junk' and weight z scores ($r .111$; $P < .021$), BMI z scores ($r .099$; $P .017$), and waist to height ratio ($r .098$; $P .018$), hip circumference ($r .131$; $P < .031$) and mid arm ($r .141$; $P < .011$). Significant positive correlation was also observed between scores for dietary pattern 3 'healthy' and height z scores ($r .092$; $P .026$). However, no significant correlations were observed between scores for 'Processed dietary patterns' and measures of children's anthropometry (table 5.4).

Dietary patterns and BMI categories factors

An ANOVA was performed to investigate differences in mean dietary pattern scores and children's BMI z scores. The findings show a significant difference between 'Junk' dietary patterns in children in the obese category compared to children in the healthy category ($P .033$). Although the findings did not show a significant difference for other dietary patterns by BMI category of children, it showed that children who were in the normal weight category at 6 years of age had a lower mean Processed and Junk component scores when compared to children at overweight and obese category (table 5.5).

Multiple regression analysis are provided in (table 5.6) and shows the relationship between dietary component scores and children anthropometry for age, sex, mother's education, mothers BMI, energy intake. The (model-II) shows no correlation were observed between scores for 'all dietary patterns' and measures of children's anthropometry.

Discussion

Overall, three dietary patterns were found using principal component analysis of dietary data collected from offspring of participants in the HAPO Belfast cohort. The first dietary pattern was ‘processed diet’ which was associated with high loadings for intakes of beef, fish, pizza, peanut, chips, ice cream, potatoes, eggs, bun, bacon, pork, rice, pasta and fizzy drinks and therefore is slightly similar to the meat and two vegetables diet that is traditionally consumed in Northern Ireland (Barker et al., 1992). The second ‘junk diet’ dietary pattern had high loadings of foods high in fat and/or sugar, including chocolate, crisps, sweets, yoghurt, cereal, bread, fruit squash, biscuits, cheese, butter. The third dietary pattern identified was ‘healthy diet’ and was associated with intakes of fruit and vegetables, eggs, fish, brown rice, wholemeal bread and pasta, fish oil, porridge and cheddar cheese.

These results may be compared with the outcomes of a study conducted in England (Northstone & Emmett, 2005) in which completed PCA utilising FFQ data gathered on children from the ALSPAC study during 1991 and 1992 (n=17,836) in order to detect dietary patterns in children aged from four to seven. The following three patterns were detected in the ALSPAC cohort: ‘health consciousness’, ‘traditional’ and ‘junk’. Encouragingly, many aspects of the dietary patterns observed in the ALSPAC research are consistent with the outcomes of this present research. The ‘*health conscious*’ pattern is additionally related with consumption of fish, pasta, fruit and vegetables, cheese, and rice which indicate how it is possible for general themes to be detected across researches even when contrasting methods are used to data analysis. The ALSPAC study ‘*traditional*’ pattern was linked with consume of potatoes and vegetables. However, it was not linked with meat consumption. Additionally, the ALSPAC ‘*Junk*’ pattern was linked to consume of high-fat processed diet, such as burgers, sausages and coated poultry. It was also related to snack diet high in fat and/or sugar, including chocolate,

crisps, sweets, ice creams and ice lollies.) This would indicate that the reproducibility of the PCA method utilised in the detection of dietary patterns is robust and validating our methods.

Another study which identified dietary patterns in children aged 2 years old in Spain (Aranceta et al., 2003) identified five main components of dietary patterns. The first was a ‘snacky’ pattern characterized by higher consumption of buns, cakes, biscuits, sweets, salted snacks and soft drinks; a ‘healthy’ pattern was associated with increased intake of fruit, vegetables and fish; a ‘protein-rich’ pattern was characterized by frequent consumption of pulses, eggs, dairy products and cereals, a ‘meat-rich’ pattern was associated with all meat products and a pattern with a high loading on soft drinks. The factors found in this study were not consistent with our study as it was related to Spanish children. This shows a limitation of the PCA method since it is population-specific.

However, in adults a general methodological approach was carried out to determine dietary patterns in each population and evidence suggests that some significant dietary patterns were shared by the four samples although some were country-specific (Balder et al., 2003).

Balder et al (2003) advocated that ‘food choices must be driven by endogenous factors (e.g. biological, psychological), whereas other patterns are more clearly the result of sociocultural circumstances and food availability’. Studies in adults have demonstrated a good reproducibility (Togo et al., 2003) however additional study is needed in child samples in the United Kingdom in order to establish the level of reproducibility of the PCA techniques in that population.

However, some adult studies which were conducted in the UK reported comparable patterns to those reported in this paper. Particularly, Whichelow and Prevost, (1996), Barker et al., (1990) and Gregory et al., (1990), each of whom reported dietary patterns which loaded highly on a similar ‘traditional British diet’, ‘healthy foods’, and a ‘convenience, snack and pattern of

processed foods'. Furthermore, similar patterns were found by Mullen et al. (2000), such patterns had high-factor loadings for 'vegetables, fruit and yoghurt' (healthy), 'traditional hot meal accompaniments' and 'snacks and processed foods'.

Some limitations associated with the application of PCA regarding reproducibility over samples and the subjective decisions required by researchers (Martinez et al., 1998; Jacques & Tucker, 2001; Trichopoulos & Lagiou, 2001; Hu, 2002). Nevertheless, this is more extensively employed as another option to the study of nutrient intake especially when examining particular results like: coronary heart disease (Osler et al., 2002), colon cancer (Slattery et al., 1998), endometrial cancer (McCann et al., 2001) as well as obesity and cardiovascular disease (Fung et al., 2001; Togo et al., 2001). The current study calculated a response rate ranging from 59 to 68% of the original cohort. There is consequently the possibility that some bias could have been incorporated into the analysis process. This was especially the case as non-responders were discovered to be disproportionately from lower social groupings. It has been identified that such variables can influence the responses here under investigation. Additionally, the questions analysed only covered foods that the mother had provided. Thus no inclusion for food that might have been consumed between the ages of four and seven outside the home such as in school. However, the majority of the food that a child consumes is provided by the mother or carer. Therefore, it is likely that this food provided outside home will reflect home life to a large degree. In view of the present trends in childhood obesity which can occupy a significant function in the disease processes of adulthood, there is need to investigate the impacts on child growth of the eating patterns identified in this paper. Every type of food which is eaten, occupies a place in overall nutrition, and a method of summarising them is useful.

When the relationship between children's dietary patterns and nutrient intakes was investigated in the present study, the 'healthy' dietary pattern was positively correlated with energy intakes (Kcal), protein, CHO, fibre, NSP, Vitamin A, retinol, carotene, and vitamin, B6, B12 and

Vitamin C for both genders. Positive relationships were also found between the HAPO 'Junk' dietary pattern and intakes of energy (Kcal), carbohydrate, total and free sugar. This indicates that the confectionary diet can lead to high calorie intake and eventually may lead to obesity. Northstone and Emmett, 2005 had similar findings with the ALSPAC 'Junk' dietary pattern being associated with carbohydrates and sugars.

The results of the partial correlation analysis (between scores for each of the three dietary patterns determined) as well as the children's anthropometry information in the present study indicated positive relationships between the scores of the HAPO study 'Junk' dietary pattern and participant BMI, weight, and waist-to-hip ratio. The significant correlations were sustained after adjustment had been made to account for the co-variables such as age, gender, and BMI. These significant correlations remained after adjustment for gender, BMI and age. This indicates that the children's diet containing high sugar might be a strong clue for their obesity. However, when more co-variables influence children's diet there were no link between all dietary patterns and participant BMI, weight, and waist-to-hip ratio.

These findings are comparable to those of a Chinese study carried out by Zhang et al., (2015) in China to investigate children's food intake at 7 years of age in relation to weight gain and health outcomes. The findings showed that modern and traditional foods with high fat and sweet content are associated with increased risk of obesity.

In the present study, the subjective nature of principal component analysis is a possible limitation because it requires researchers to take decisions on the number of components generated which may lead to the type and number of dietary patterns detected and analysed. However, the results in the present study are consistent with those identified in the ALSPAC research that utilised an FFQ. In fact, the present study's FFQ was adapted from the ALSPAC study. These congruent findings indicate acceptable reproducibility in PCA methods utilised.

to determine the dietary patterns. A further limitation within the current study was that, due to study design of the HAPO study, BMI data for children were not available for all 1639 participants.

Conclusion

Overall, three dietary patterns were identified in the diets of these participants. These were the 'healthy', 'Processed' and 'junk'. The 'healthy' pattern was positively associated with protein, carbohydrates, fibre, vitamins while the 'confectionary' pattern was positively associated with carbohydrate and sugars. Associations between dietary patterns and obesity were observed with 'Junk' dietary patterns which were positively associated with measures of child anthropometry at 6 years of age. These findings suggest that children who consumed a diet higher in sweet foods at 6 years of age may be at increased risk for obesity. This indicates that dietary interventions should commence early in life to establish healthy eating patterns.

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Table 5. 1: General characteristics of children from HAPO study at 6 years

	Male		Female		
	Mean	SD	Mean	SD	P
Age (years)	6.03	0.36	6.01	0.36	0.467
Height (cm)	116.46	5.34	116.12	5.05	0.434
Weight (kg)	22.05	3.53	22.3	3.76	0.405
Hip circumference (cm)	60.44	4.72	61.45	4.97	0.013
Waist circumference(cm)*	54.9	5.0	55.9	5.9	0.019
Height z scores	0.11	0.97	-0.06	0.97	0.002
Weight z scores*	0.34	1.0	0.34	1.1	0.893
BMI z scores *^b	0.4	1.0	0.5	1.1	0.021

All values are presented in Mean and standard deviation; *Significant mean difference at $P=0.005$

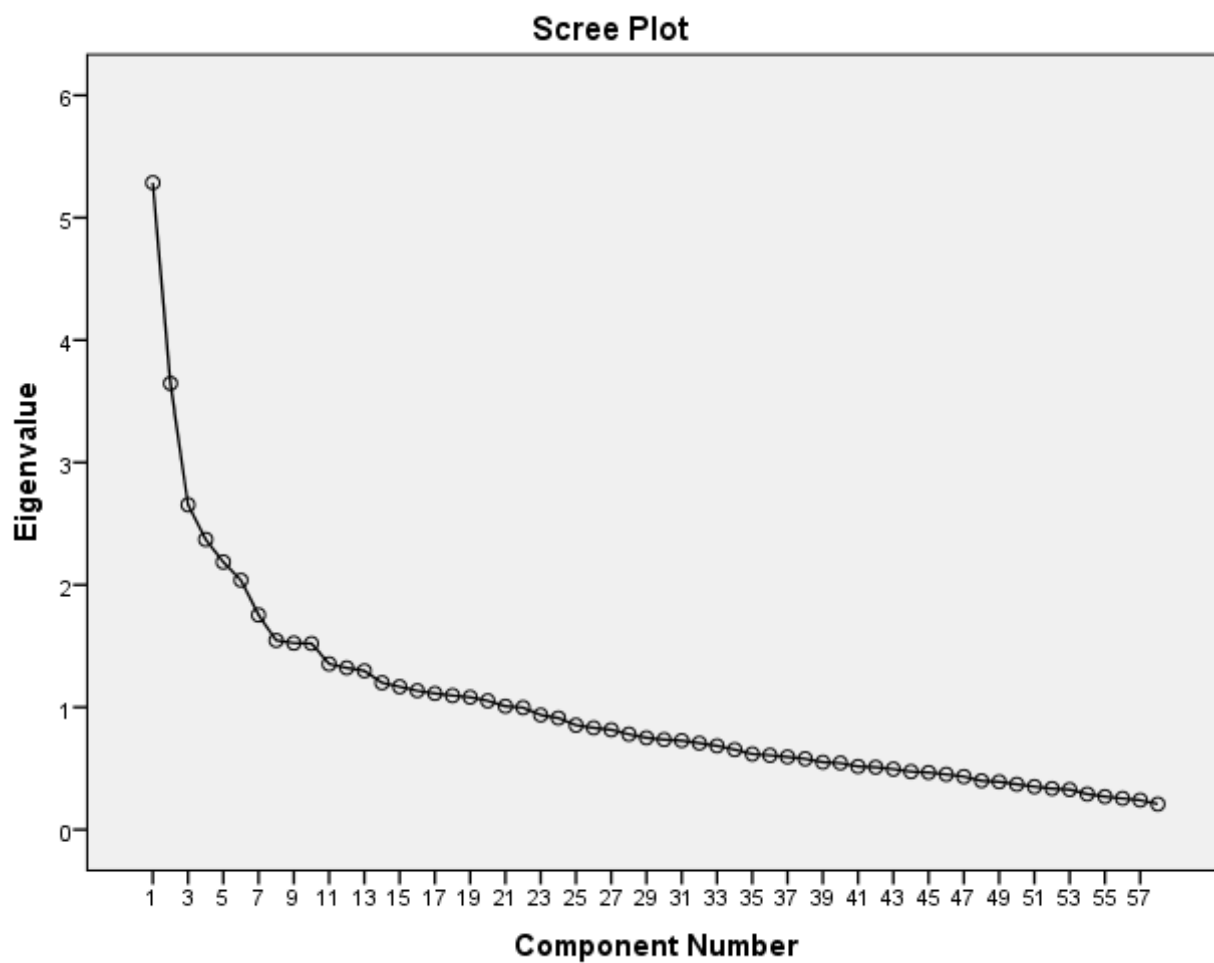


Figure 5.1. Scree Plot of Eigenvalues of dietary components extracted from FFQ data using principal components analysis with varimax rotation

Table 5.2 Factor loadings for foods /food groups within each of three dietary patterns identified in 6-year-old children using FFQ (factors loadings >0.3 in bold)

Rotated Matrix	Dietary factor 1 'Western/junk'	Dietary factor 2 'Confectionary'	Dietary factor 3 'Healthy'
Fish finger	0.626	-0.007	-0.032
Beef burger	0.609	0.136	-0.170
Pizza	0.596	0.024	-0.027
Peanut	0.552	-0.026	0.144
Chips	0.506	0.111	-0.272
Ice-cream	0.490	0.108	-0.066
Sausages	0.487	0.102	-0.239
Roast potatoes	0.476	0.046	-0.074
Eggs	0.466	0.099	0.308
Bacon	0.432	0.015	0.020
Buns	0.431	0.131	0.057
Pork	0.378	-0.033	0.108
Fizzy soft drinks	0.358	0.248	-0.188
White pasta	0.357	0.036	0.269
White rice	0.324	-0.121	0.213
Crackers	0.307	0.060	0.042
Cakes	0.290	0.229	-0.004
Boiled mashed potatoes	0.280	0.162	0.093
Chicken	0.280	0.008	0.190
Beef	0.279	-0.010	0.216
Baked beans	0.189	0.141	0.049

Crisp bread	0.179	0.037	-0.040
Margarine	-0.043	-0.007	0.001
Chocolate	0.137	0.737	-0.116
Crisps	0.162	0.670	-0.217
Sweets	0.176	0.669	-0.120
Ham	0.015	0.533	0.109
Full fat yoghurt	-0.006	0.442	0.048
Low fat yoghurt	-0.057	0.410	0.246
Other cereals	0.024	0.406	-0.040
White bread	0.136	0.402	-0.212
Fruit squash	0.281	0.401	-0.114
Biscuits	0.140	0.387	-0.090
Cheese	-0.115	0.366	0.095
Butter	0.104	0.365	-0.072
Sugar free fruit squash	-0.001	0.345	0.026
Fruit juice	0.072	0.298	0.214
Milk	0.011	0.254	0.242
Diet fizzy soft drinks	0.052	0.155	-0.148
Whole milk	0.066	0.080	0.028
Other vegetable	0.066	-0.081	0.640
Green vegetable	0.120	-0.027	0.606
Fruit	-0.122	0.189	0.479
Salad	0.355	-0.074	0.445
Brown rice	-0.048	-0.027	0.441

Other fish	0.177	-0.100	0.393
Wholemeal bread	-0.155	-0.089	0.391
Oil fish	0.063	-0.164	0.387
Wholemeal pasta	-0.102	-0.051	0.386
Cheddar cheese	0.120	0.192	0.309
Porridge	0.166	-0.056	0.308
Brown bread	0.117	0.038	0.262
Salad cream mayo	0.056	-0.013	0.258
Low fat spread	-0.103	0.023	0.255
Lamb	0.021	0.099	0.155
Semi skimmed milk	-0.033	0.046	0.136
Skimmed milk	0.078	0.055	0.106
Very low fat spread	-0.040	-0.024	0.097

Table 5.3 Correlation coefficients of partial correlation analysis between dietary component scores and mean daily nutrient intakes for (n=566)

	Dietary factor 1 ‘Processed’		Dietary factor 2 ‘junk’		Dietary factor 3 ‘Healthy’	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Energy (Kcal)	.008	.876	.113	.015*	.089	.056
Protein	.025	.273	.022	.641	.208	<0.001*
Total fat	.028	.539	.079	.090	.031	.497
Carbohydrate	.006	.592	.140	.002*	.136	.003*
Sugars	-0.102	0.068	.115	.013*	.211	<0.001*
Fibre	0.071	0.123	.049	.290	.271	<0.001*
NSP	0.200	0.698	.007	.898	.230	<0.001*
Vitamin A	.010	.854	.046	.385	.266	<0.001*
Retinol	.061	.168	.009	.824	.130	.005
Carotene	.111	.286	.061	.188	.262	<0.001*
Vitamin D	.050	.281	.064	.319	.152	<0.001*
Vitamin E	.001	.995	.013	.758	.066	0.224
Vitamin K	.039	.455	.046	.378	.213	<0.001*
Thiamine	.039	.104	.034	.456	.125	.007*
Vitamin B6	-.109	.018	.080	.083	.114	.013*
Vitamin B12	.064	.167	.045	.323	.218	<0.001*
Vitamin C	-.093	.033	.046	.321	.294	<0.001*

* Significant correlation at *P*.005

Table 5.4 Correlation coefficients of partial correlation analysis between dietary component scores and children anthropometry after adjustment for age, gender, and BMI (n=566)

	Dietary component 1 ‘Processed’		Dietary component 2 ‘ Junk ’		Dietary component 3 ‘ Healthy ’	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Weigh z scores	0.019	0.530	.039	.022*	0.111	0.320
Height z scores	0.021	0.496	0.041	0.173	0.092	0.026*
BMI Z scores	0.054	0.196	.099	0.017*	0.068	0.103
Head circumference (cm)	0.016	0.594	0.041	0.179	0.037	0.220
Waist/hip ratio	0.028	0.502	0.013	0.749	0.006	0.879
Triceps (mm)	0.029	0.332	0.010	0.734	0.075	0.082
Subscapular (cm)	0.038	0.207	0.006	0.841	0.092	0.122
Mid arm (cm)	0.002	0.937	0.117	0.005*	0.085	0.235
Body fat percentage (g)	0.056	0.191	0.044	0.304	0.017	0.697

* Significant correlation at *P*.005

Table 5.5: Mean differences of dietary pattern by children BMI categories at 6 years

	Normal weight		Overweight		Obese		
	Mean	SD	Mean	SD	Mean	SD	<i>P</i> *
Dietary component 1 ‘Processed’	-0.002	1.06	0.031	0.93	-0.150	0.57	0.68
Dietary component 2 ‘ Junk ’	-0.012	0.77	-0.024	0.65	0.316	2.37	0.038
Dietary component 3 ‘ Healthy ’	-0.020	0.90	-0.060	0.99	0.198	1.06	0.38

**P* value assessed by one way ANOVA and significance established at $p < 0.05$. ANOVA was performed to investigate differences in mean dietary pattern scores and children’s BMI z scores categories.

Values shown are mean intakes; SD, Standard deviation

†

Table 5.6. Multiple logistic regression analysis between dietary component scores and children anthropometry (n=566)

Model 1	Dietary component 1 ‘Processed’		Dietary component 2 ‘ Junk ’		Dietary component 3 ‘ Healthy ’	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Weight z scores	0.019	0.530	.039	.022*	0.111	0.320
Height z scores	0.021	0.496	0.041	0.173	0.092	0.026*
BMI Z scores	0.054	0.196	.099	0.017*	0.068	0.103
Head circumference (cm)	0.016	0.594	0.041	0.179	0.037	0.220
Waist/hip ratio	0.028	0.502	0.013	0.749	0.006	0.879
Triceps (mm)	0.029	0.332	0.010	0.734	0.075	0.082
Subscapular (cm)	0.038	0.207	0.006	0.841	0.092	0.122
Mid arm (cm)	0.002	0.937	0.117	0.005*	0.085	0.235
Body fat percentage (g)	0.056	0.191	0.044	0.304	0.017	0.697
Model 11	Dietary component 1 ‘Processed’		Dietary component 2 ‘ Junk ’		Dietary component 3 ‘ Healthy ’	
	β	<i>P</i>	β	<i>P</i>	β	<i>P</i>
Weight z scores	0.030	0.830	0.042	0.204	0.543	0.300
Height z scores	0.025	0.601	0.158	0.815	0.935	0.931
BMI Z scores	0.054	0.286	0.172	0.658	0.723	0.621
Head circumference (cm)	0.030	0.674	0.032	0.912	0.104	0.793
Waist/hip ratio	0.128	0.802	0.030	0.760	0.685	0.291
Triceps (mm)	0.023	0.443	0.017	0.673	0.075	0.369
Subscapular (cm)	0.138	0.3807	0.020	0.748	0.092	0.489
Mid arm (cm)	0.025	0.806	0.214	0.425	0.341	0.944
Body fat percentage (g)	0.023	0.274	0.304	0.934	0.011	0.838

Multiple regression test .Model- I, without adjustment (simple correlation); model -II, adjusted for age, sex, mother’s education, mothers BMI, energy intake

Chapter 6

**Contribution of dietary carbohydrates, sugars and fibre in the
development of childhood obesity**

Abstract

Background

The incidence of childhood obesity has risen dramatically in the past three decades. Obese children are at an increased risk of a range of health consequences, including cardiovascular risk factors, type II diabetes and low self-esteem. Obesity occurs when energy intake exceeds energy expenditure.

Objective

The aims of the current study are to investigate the association between dietary carbohydrate intake and childhood obesity at 6-years. Secondly, to investigate the differences in dietary carbohydrate between children based on their BMI's. Finally, to identify the major sources of Free sugars and their contribution to Free sugar intakes in the diets of children.

Methods

Four-day food diaries from a sample of 1023 children, were analysed using Nutritics dietary software. A subset of diaries (n=125) was analysed to determine free sugar intake and its contributing sources.

Results

No significant difference in BMI between genders was observed, however boys consumed significantly more energy ($P<.001$), carbohydrates ($P<.001$), total sugars ($P.006$), free sugars ($P.002$), and total fat ($P.013$) than girls. Obese children consumed significantly less fibre than healthy weight children ($P.036$), but no relationship was observed for sugars and BMI. The major source of free sugars in the diet was sugar sweetened beverages (28%) and a significant negative correlation was observed between fibre intake and percentage free sugars to energy (r -.103, P .012).

Conclusion

Obese children consumed less fibre than healthy weight children and fibre intake was inversely associated with the percentage of free sugar in the diet. No significant relationship occurred between free sugar intake and BMI in children, with the highest source of free sugars being sugar sweetened beverages. Future public health strategies should focus on the beneficial role of fibre in a child's diet.

Introduction

Obesity is a major public health challenge with worldwide obesity rising dramatically over the past three decades in both adults and children (Finucane et al., 2011). The World Health Organisation (WHO) estimated that 42 million children under the age of 5 were obese in 2013 (WHO, 2013). In the UK alone, 29% of 2-15 year olds are overweight and 15% are obese (Public Health England, 2013). Childhood obesity is a complex multi-system disorder that can affect almost every organ in the body (Ebbeling et al., 2002; Daniels, 2009). As with obesity in adulthood, childhood obesity can lead to chronic conditions including cardiovascular disease and type II diabetes (Lakshman et al. 2012). Additionally, increased health care costs and premature deaths occur as a result of childhood obesity (Franks et al., 2010; Trasande and Elbel, 2012).

It is widely accepted that obesity results from an imbalance between energy intake and energy expenditure. (Lustig, 2001; Sahoo et al., 2015). As a result of this, any external factor that increases energy intake or decreases energy expenditure over time can result in weight gain, ultimately leading to childhood obesity. The UK Foresight report has identified over 100 different factors which can affect energy balance at an individual, household or environmental level (Bustland et al., 2008). These include sedentary behaviour, physical inactivity, large portion sizes and energy-dense foods.

Evidence has shown that children with a higher body weight have a more energy dense diet than lean children (Vernarelli et al., 2011). Dietary fat often receives negative press due to being the most energy-dense macronutrient but controversy surrounds the optimum macronutrient composition required to achieve a healthy diet in childhood (Moreno and Rodríguez, 2007, Han et al., 2010). Studies looking at the role dietary fat plays in childhood obesity have had inconsistent conclusions. It has been shown that an increased percentage fat intake is significantly related to increased body weight in children (Johnson et al., 2008). In

contrast, other observational studies have failed to identify such a relationship (Brixval et al., 2009). Carbohydrates also contribute to total energy intake, with a potential to cause a positive energy balance (van Dam and Seidell, 2007). The effects of different carbohydrates are related to the type of carbohydrate, their rate of digestibility and their physical function in the gastrointestinal tract (Brown et al., 2010). Evidence suggests that high glycaemic index (GI) carbohydrates are associated with increased adiposity, whereas high fibre, low glycaemic index carbohydrates may be protective (Gibson et al., 2006). The proposed mechanism behind this theory is that low GI foods have a higher satiety, higher metabolic rate, higher fat oxidation, and reduced postprandial glycaemia compared to high GI foods (Ludwig 2002, Alviña and Araya, 2004). The EURODIAB Complications study found that the consumption of low glycaemic index foods is independently related to lower body weight in adults (Toeller et al., 2001).

The recently published Scientific Advisory Committee on Nutrition (SACN) report found that increasing or decreasing total energy intake from sugars leads to a corresponding increase or decrease in energy intake (SACN, 2015). Sugar-sweetened beverages, which include carbonated soft drinks and fruits juices, are the largest source of free sugars and contribute a significant amount of energy to the diets of children in the UK (Bates et al., 2014). If an increased intake of sugar sweetened beverages (SSB) is not met with a subsequent reduction in food intake or increased physical activity, energy intake will increase and may lead to obesity (Hall et al., 2011). Evidence to date on free sugars, in particular SSBs and their role in the development of childhood obesity is conflicting. Forshee et al., 2008 reported no association between body mass index and SSBs whereas Malik et al., 2013, concluded that a high consumption of SSBs promotes weight gain in both adults and children (Forshee et al., 2008, Malik et al., 2013). The SACN concluded that while there was a positive relationship between SSBs and BMI, there is limited evidence and further research is required (SACN, 2015).

In contrast to free sugars and sugar sweetened beverages, dietary fibre is thought to have a protective role in the diet (Gibson et al., 2006). The proposed mechanisms for the role of high fibre in weight management include a reduced caloric density of the foods, slower rates of food ingestion and possible effects on satiety (SACN, 2015, Kendall et al., 2009). Observational studies have found that lean adults have significantly higher intakes of fibre than their obese counterparts (Miller et al., 1994). Reviews have also shown that fibre intake is inversely related to body weight, body fat and body mass index (Slavin, 2005). It has been found that a lack of dietary fibre in the diet is associated with greater adiposity in British children (Johnson et al. 2008).

It is hypothesized that children with higher BMI's have diets higher in free sugars and lower in dietary fibre compared to those with lower BMI's.

The aims of the current study are to investigate the association between dietary carbohydrate intake and childhood obesity at 6-years. Secondly, to investigate the differences in dietary carbohydrate between children based on their BMI's. Finally, to identify the major sources of Free sugars and their contribution to Free sugar intakes in the diets of children.

Study protocol

Background to study

Subjects were participants in the Belfast cohort of Hyperglycaemia and Adverse Pregnancy Outcome (HAPO) study. This is an observational prospective study that aimed to clarify unanswered questions in relation to the association of maternal glycaemia with risks of adverse pregnancy outcomes. The study was a multi-centre study with 15 centres across nine countries being involved. The Belfast centre recruited 1639 pregnant women between October 2001 and September 2006 in accordance with specific inclusion and exclusion criteria (HAPO Group , 2002).

At approximately six years post-partum, participants and their offspring were invited back to take part in the follow up study. This follow up study investigated the development of obesity on metabolic health. Of the original Belfast cohort, Anthropometric, dietary and biochemical data was obtained from both the mother and the child (aged approximately 6 years) and available for analysis of this study.

Ethical approval

Ethical approval was obtained from Queen's University Belfast and the Biomedical Sciences Ethics Filter Committee at Ulster University (FCBMS-14-030). Each mother was allocated a unique identification number which was used throughout the project. Therefore the participants remained anonymous to the researchers.

Data collection

Food diaries

Participants completed a 4-day semi quantitative food diary on behalf of their offspring at this visit. The food diaries included 2 weekdays and 2 weekend days. The mothers were asked to record everything their child consumed and drank within this time period. A nurse gave detailed instructions to participants on completion of the diaries. All foods, drinks and snacks consumed throughout the day were recorded, including those that were consumed outside of the home for example school. Portion sizes were estimated using household measures (e.g. bowl of cereal, glass of milk or natural unit sizes e.g. a potato).

Anthropometry

Body weight and height of the child was measured at the visit using standardised procedure. Hip circumference and waist circumference was recorded. Skinfold thickness was measured at four different sites; the biceps, triceps, subscapular and suprailiac muscles using calipers. BMI

measurements of the children were based on the thresholds of the UK 1990 growth reference chart (Cole *et al.* 1995) and this data was then categorised into BMI centiles. In order to determine the child's BMI status, BMI Z scores, also referred to as BMI standard deviation (SD) scores were formulated. Children were classified as underweight ($\leq 2^{\text{nd}}$ centile), healthy weight ($>2 - <85^{\text{th}}$ centile), overweight ($\geq 85^{\text{th}}$ centile) or obese ($\geq 95^{\text{th}}$ centile) using "LMS Growth" Microsoft Excel add-in software.

Data analysis

Dietary Analysis

In order to convert the qualitative data on food intake into quantifiable data, food diaries were entered into Nutritics dietary software analysis. Portion sizes were determined using the resource "What's enough?" to enforce a standardised procedure using age and sex specific portion sizes (Nutrition and Diet Resources UK 2013). The output from Nutritics was used to get an insight into the child's intake of the major macronutrients, in particular energy (kJ/kcal), carbohydrates (g/% total energy), total sugars (g), free sugars (g) fibre (g) total fat (g) and saturated fat (g).

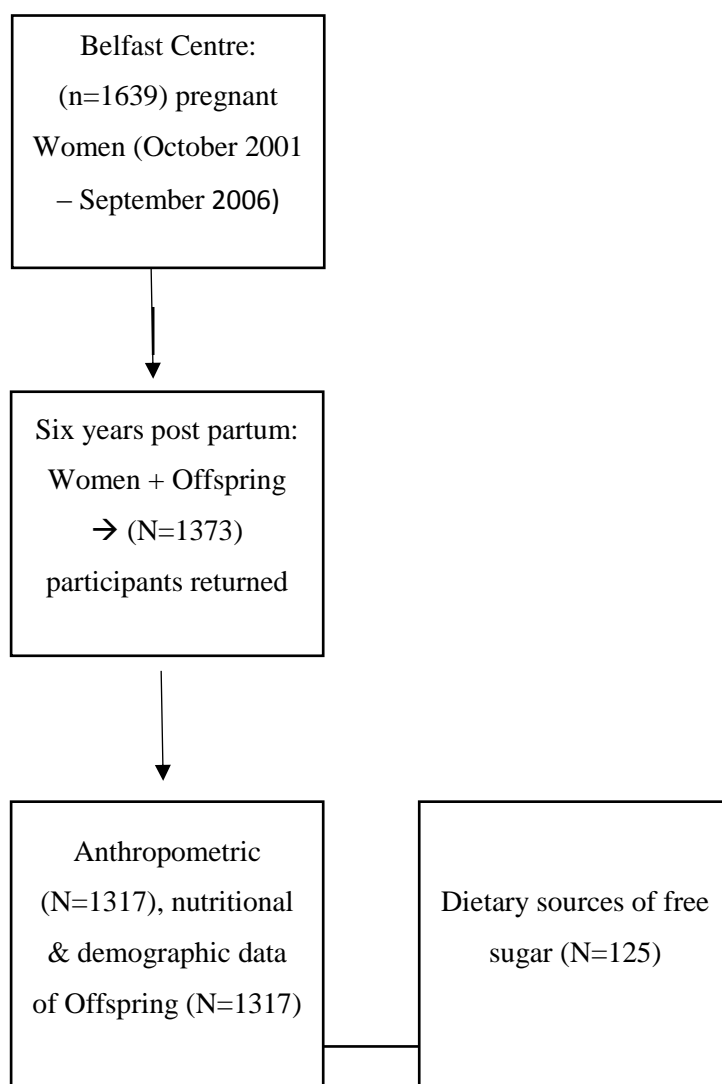
Free sugars

A subset (n=125) of the food diaries were further analysed to examine the major contributing sources of free sugars in the diet. The subset of the food diaries were selected randomly and reason for analysing that number of subset is because only 125 food diaries were further completed and analysed as the way (the sources and quantity of free sugars were divided into five major groups):

- 1) Non-alcoholic beverages (Sugar sweetened beverages and fruit juices),
- 2) Cereal and cereal products (biscuits, buns, cakes, puddings, breakfast cereals),

- 3) Sugar, preserves and confectionary (Sugar confectionary, chocolate confectionary, sugar, preserves and spreads,
- 4) Milk products (yogurt, fromage frais, dairy desserts and ice cream)
- 5) Other (Canned sauces and other foods that did not fit under any other group).

Figure 6.1



Flow diagram of the number of participants included and returned for the HAPO study

Statistical analysis

All data was analysed using Statistical Package for the Social Sciences (SPSS) software version 22.0. The mean, standard deviation and range for all continuous variables was determined using descriptive statistics. Categorical variables were presented as frequencies and percentages. The level of significance used was $P < 0.05$. Nutrient intakes were checked for normality using the Kolmogorov-Smirnov test and those intakes that were skewed were transformed. Independent t-tests were used to determine significant differences in anthropometric and dietary data between male and female subjects. Chi-squared tests were used to examine the differences in BMI between genders and also to determine the level of under-reporting based on BMI Z Scores. A one-way ANOVA was used to look at the relationship between BMI categories and dietary intake, in particular sugars, carbohydrates and fibres. Correlations between certain nutrients were determined using Spearman's correlation. In order to show the major sources of free sugars, a histogram was generated using Microsoft excel software.

Mis-reporting

Potential under-reporting of energy intake was determined using the EI:BMR ratio and the Goldberg cut-off point (Black 2000). Gender and age-specific Schofield equations were used to determine the basal metabolic rate of the children (ESPGHAN 2005). Potential mis-reporters were categorised as subjects that had an EI:BMR ratio of ≤ 1.2 and definite under-reporting was determined as having an EI:BMR ratio of <0.9 . Those with an EI:BMR ratio >1.2 were classified as having reported intake appropriately.

Many procedures were implemented in order to verify the intake validity of child participants. Participants were requested to record in food diaries if the recorded intakes were accurate and were of the usual dietary patterns or whether there had been any endeavour to adjust intakes within the recording period. Furthermore, there was an estimation of misreporting in order to establish the proportion of plausible reporters by BMI and gender classifications. Misreporting

was categorised as $[(EI - TEE)/TEE] \times 100\%$ in combination with the Goldberg technique ranges adjusted for children (Livingstone et al., 2003) with an estimated PAL of 1.57 for six-year-olds children (FAO/WHO/UNU, 2001), to define plausible range (0.7-1.42), under- (<0.7) and over-reported intakes (>1.42).

Results

A total of 1317 children had nutritional, anthropometric and demographic data available for analysis.

Table 6.1 presents the children's anthropometric characteristics and shows that for the total group (n=1317), there was no significant difference between male and female participants except in the case of waist circumference ($P = 0.019$) and hip circumference ($P = 0.013$). Males had significantly greater waist and hip circumferences than females. This difference was not observed in the free sugars group (n=125). No significant differences were observed in this group for any anthropometric measurements.

Table 6.2 shows the percentage of children within each BMI category based on UK90 Z scores. The majority of children (72.4%) were in the healthy weight category. The next highest group was overweight children, followed by obese and, finally underweight. There was no significant difference in BMI between genders ($P=0.209$). Similarly, in the free sugars group, the highest percentage of children were in the healthy weight category (68.6%) No children in the free sugars group were underweight.

Table 6.3 displays the dietary intakes between genders. Boys consumed significantly higher intakes of energy than girls (Boys =1563 kcal, Girls =1473kcal ($P<.001$)). This was also the case for carbohydrates (g) ($P<.001$), total sugars (g) ($P=.006$), free sugars (g) ($P=.002$) and total fat (g) ($P=.013$) (Table 6.3).

Table 6.4 shows that there was no relationship found between body mass index and energy intake, total sugars or free sugars. It was found that obese children consumed significantly less carbohydrate than overweight children ($P.034$). Healthy weight children consumed significantly higher intakes of fibre than obese children ($P. 036$), with healthy weight children consuming a mean intake of 13.5g compared to obese children consuming 12g.

Table 6.5 presents the relationship between the sources of free sugars consumed and body mass index. Obese children had higher mean intakes of sugar-sweetened beverages than overweight and healthy children but this relationship was not statistically significant.

Table 6.6 shows the mean intakes of the various sources of free sugars between boys and girls. Boys had higher mean intakes than girls for all four groups (SSB/Cereals/Confectionary/Milk), however this trend was not significant.

Table 7.6 A significant inverse relationship was observed between fibre intake (g) and percentage free sugars to total energy intake but the correlation was weak ($r.103$). When fibre (g) intake increased, there was a significant increase in percentage carbohydrates to total energy and percentage total sugars to total energy.

Figure 6.2 shows the contributing sources of free sugars in the diets of the children. 12.6% of total energy was derived from free sugars. Sugar sweetened beverages were the biggest contributor to free sugar intake in 6-year-old children, followed by confectionary, cereal and cereal products and finally milk products.

Figure 6.3 shows that, for the total group, only 11% of subjects were classified as potential under-reporters. No under-reporters were identified in the underweight group. The group with the highest proportion of potential under-reporting was the obese children (41%), followed by the overweight and finally, the healthy weight children.

Discussion

This study aimed to investigate the relationship between dietary intakes, in particular carbohydrate foods and body mass index in children. Secondly, dietary differences between gender and the major sources of free sugars in the diets of young children were examined. Although the cause of childhood obesity is likely to be multifactorial, the findings in the current study suggest that children who consumed more fibre in the diet were more likely to be of a healthy weight whilst those who had a lower fibre diet were more likely to be obese, suggesting that diets lower in fibre may contribute to the development of obesity.

In the current study, 19% of children were overweight and 7.4% were obese. These results differ from recent figures by Public Health England, showing that 9.1% of children aged 4-5 years were obese and a further 12.8% were overweight (Public Health England, 2015). In Ireland it is estimated that 1 in 4 children are obese (Heinen et al., 2014). The current study found a smaller proportion of children to be obese (7.4%). However, this may be as a result of the sample size which may not be reflective of the entire population.

The current study shows that, despite significant differences in waist circumference and hip circumference between genders, there was no significant difference in body mass index (P .209). These results are similar to a study carried out on 6-8 year-old English children, with boys having a significantly greater waist circumference than girls, yet there was no difference in BMI between the genders (Basterfield et al., 2014). However, abdominal obesity has long been recognised as a risk factor for a number of obesity-induced co-morbidities including cardiovascular disease and type II diabetes (Cameron et al., 2009). It is believed that waist circumference and abdominal obesity are better indicators of obesity related health risks than body mass index (Janssen et al., 2004; Lee et al., 2008).

A difference in dietary intake was observed between genders. This study showed that males consumed significantly more energy than females, with males consuming a mean intake of 6562kJ (1563kcal) compared to females consuming 6184 kJ (1473 kcal). The current UK dietary reference values for 6-year-old boys and girls are 1577 kcal and 1482 kcal respectively which are very close to our current findings. The kcal intakes in this study are lower than the NDNS findings in UK children aged 4-10 years (1776 kcal), (Bates et al., 2014). The difference in findings may be as a result of a smaller sample size which is not representative of the entire population. As well as energy intake, it was observed that boys consumed more carbohydrates, total sugars, free sugars, and total fat than girls. These findings are consistent with other studies looking at the differences in intake between genders (Alexy et al., 2002; Glynn et al., 2005, Merkiel, 2014). However, despite the increased intakes of these nutrients, no difference in body mass index between sexes was found in the current study. This is similar to findings on 2-10 year-olds participating in the European IDEFICS study where boys were found to consume more energy than girls, but there was no significant difference in BMI between groups (Hebestreit et al., 2016).

The mean intake of fibre (AOAC method) in the current study was 13g/day. The recent NDNS findings on UK children showed a lower mean intake of 11.1 -11.8g/day in children aged 4-18 years (Bates et al., 2014). The current study is similar to US data, with the NHANES data reporting a mean intake of 13.2g/day of fibre in children and adolescents (McGill et al., 2015). The findings reported in the current study contribute to the evidence indicating that obese children have diets lower in fibre than healthy weight children. Obese children consumed significantly less fibre (12g/day) than healthy weight children (13.6 g/day) (P .036), which was in line with an American study that examined the NHANES data on 2-18 year olds and found that the risk of overweight/obesity decreased as a result of increased fibre intake (Brauchla et

al., 2012). Similarly, a study carried out on Latino youth found that an increase in total dietary fibre was associated with a decrease in adiposity (Davis et al., 2009).

In the current study, 12.6 % of total energy was derived from free sugars, exceeding the current recommendations of 10%. A similar study carried out on NDNS subjects aged 4-10 showed a higher intake (14.7%) than the current study (Bates et al., 2014). The lower percentage of free sugar intake in the current study compared to other data may be as a result under-reporting of intake by the mothers. Evidence suggests that the level of agreement between children's reporting of their diet and those of their parents can be different, with parents reporting lower intakes of certain foods such as sugar sweetened beverages (van de Gaar et al., 2016). As the mothers filled out the diaries on behalf of their children in this study, this may have occurred. The major source of free sugars in the diet of these children was sugar-sweetened beverages (28%). This was similar to UK data from the NDNS study, with SSBs, contributing the major source (30%) of their free sugar intake. These findings are also in agreement with US data, with sugary drinks being their major source of added sugar (Drewnowski and Rehm, 2014). In the current study, the second largest source of free sugars was confectionary which made up 25% of free sugar intake. This was higher than UK data for confectionary (22%), with their second highest contributing source coming from cereal and cereal products (29%). Similarly, in the NHANES study, their second greatest source was from grain and cereal products (12.7%), followed by confectionary. In the current study only 16% of free sugar intake was from cereal products. Milk and milk products made up 17% of free sugar intake in the current study which made them the third biggest contributor. This was higher than data derived from other UK children with only 12% of their free sugar intake coming from milk and milk products (Bates et al., 2014).

No relationship was observed in total sugars or free sugars between BMI categories. These results replicate the findings of a meta-analysis carried out on twelve studies in 2008, with the

study concluding that there was no association between sugar-sweetened beverages (a major source of free sugars) consumption and BMI (Forshee et al., 2008). The 2015 SACN report looked at total sugar intake in relation to energy intake and concluded that an increase in sugar intake results in a corresponding increase in energy intake (SACN, 2015). If the energy intake is excessive this can ultimately lead to weight gain over time. The SACN also looked at free sugar intake in children and found that the consumption of free sugars in the form of sugar-sweetened beverages results in greater weight gain and increases in BMI in children. Malik et al. investigated this relationship and showed that SSB consumption promotes weight gain in children (Malik et al., 2013). The conflicting findings may be as a result of confounding factors such as activity levels in the children, maternal influences or socio-demographic background.

The current study found no difference in sources of free sugars consumed between children of varying BMI. This suggests that no single source of free sugar is associated with an increase in BMI. Despite these findings, other studies have found clear associations of SSB intake with increased energy intake and body weight (Vartanian et al., 2007). While the current study found no association, it still adds to the evidence in this area. The differences between the findings are most likely as a result of different study populations, sample size, methods and confounding factors such as under-reporting, which is a major limitation when measuring dietary intake by means of a food diary.

Less evidence is available for intakes of total or free sugars and its effect on fibre intake. A Finnish study looking at young children found that intakes of high fibre foods decreased across the quartiles of added sugar (Erkkola et al., 2009). This was also the case with Kranz et al. 2005 who found that increasing added sugar consumption was paralleled with decreasing fibre intake in 2-5 year olds (Kranz et al., 2005). A study looking at children aged up to 9 years had similar findings, showing children in low-sucrose groups consumed more grains and vegetables than those with a high sucrose diet (Ruottinen et al., 2008). This is similar to the current study

which found that those children with a higher fibre intake had a lower percentage of free sugar in the diet ($r = -.103$, $P < .012$). However, a significant positive correlation was observed for total sugars and fibre intake. This may be as a result of fruit intake in the children, which would contribute to both fibre and total sugar intake.

Some limitations should be considered when interpreting the results exist in this study. As with all dietary intake studies, under-reporting needs be considered. The assumption that the mother filled out the diary accurately is a major limitation (Livingstone et al., 2004). The percentage of potential under-reporters in this study was determined using the Goldberg cut-off point and findings were lower than other dietary intake studies looking at under-reporting in adults (Kelly et al., 2009). This may be due to the fact there was no activity data available for the child, making it difficult to establish the child's energy expenditure adequately (Livingstone and Robson, 2000). For this reason, the proportion of under-reporting in the group may be inaccurate, showing a smaller proportion under-reporting that actually occurred. Another limitation of the study could be confounding factors such as activity levels of the child and maternal influences. Future studies should incorporate these components into the study design to minimize any error in findings.

Conclusion

The current study adds support to the existing evidence on intakes and sources of carbohydrate foods and their relationship with BMI in children. The results indicate that obese children consume less fibre than healthy weight children and that fibre intake is inversely associated with the percentage of free sugar in the diet. However, there was no significant relationship shown between free sugar intake and BMI in children, with the highest source of free sugars being SSB. Future public health strategies should focus on the beneficial role of fibre in a child's diet as a strategy for reducing the incidence of obesity.

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Tables and figures

Table 6.1: General and anthropometric characteristics

*Total Group	<i>n</i>	<u>Males (54%)</u> Mean (SD)	<u>Females (46%)</u> Mean (SD)	<i>P</i>[†]
Age (years)	1317	6.03 (0.36)	6.01 (0.36)	.467
Height (cm)	1317	116.46 (5.34)	116.12 (5.05)	.434
Weight (kg)	1317	22.05 (3.53)	22.3 (3.76)	.405
Waist circumference (cm)	1317	54.5 (4.86)	55.6 (5.68)	.019
Hip circumference (cm)	1317	60.44 (4.72)	61.45 (4.97)	.013
**Free sugar group		<u>Males (N=51%)</u>	<u>Females (N=49%)</u>	<i>P</i>[†]
Age (years)	125	6 (.35)	6.1 (.31)	.789
Height (cm)	125	116 (4.9)	116.52 (4.34)	.587
Weight (kg)	125	23 (4)	22.7 (3.7)	.735
Waist circumference (cm)	125	55.4 (5.3)	56 (6.5)	.538
Hip circumference (cm)	125	61.3 (5.3)	62.3 (5)	.298

SD, Standard Deviation, BMI, Body Mass Index; Significant differences between genders were examined using Independent t tests for continuous data.† Significance was established as $p < 0.05$; * Total group represents $N=1317$; ** Free Sugar group represents $N=125$

Table 6.2: Difference in BMI Categories by gender based on UK 90 Z Scores

BMI category (Z Scores)	<i>n</i>	Underweight (<-2 SD)	Healthy (-2 – 0.9 SD)	Overweight (+1 - <2 SD)	Obese (> +2 SD)	<i>P</i>†
<u>*Total group (%)</u>	1317	1.2	(72.4%)	19	7.4	
Boys	673	1.7	75.2	17.5	5.6	.209
Girls	644	0.7	69.6	21	8.7	
<u>**Free sugars group (%)</u>	125	0	68.8	18.4	12.8	
Boys	64	0	68.3	22.2	9.5	.637
Girls	61	0	68.9	14.8	16.4	

BMI, body mass index; Values are represented as a percentage; A Significant difference between genders was determined using the Chi Squared test. † Significance was established as $p < 0.05$

*Total group ($n=1317$)

** Free Sugar Group ($n=125$)

Table 6.3: Dietary intake differences between genders

	<u>Males</u> Mean \pm SD	<u>Females</u> Mean \pm SD	P[†]
Energy (kJ)	6562.530 \pm 1321.98	6184.4 \pm 1167.34	<. 001
Energy (kcal)	1563.58 \pm 315.02	1473.66 \pm 277.90	<. 001
Carbohydrates (g)	210.68 \pm 44.98	196.94 \pm 41.08	<. 001
% CHO to total energy	54 \pm 5.43	53 \pm 5.57	.301
Total sugars (g)	99.21 \pm 31.80	92.13 \pm 29.57	.006
% sugars to total energy	25 \pm 4.57	24 \pm 8.7	.211
Free sugars (g)	51.4 \pm 23.38	45.47 \pm 23.33	.002
% free sugars to total energy	13 \pm 1.1	12 \pm 1.7	.081
Fibre	13.55 \pm 3.63	13.25 \pm 3.41	.302
% Fibre to total energy	3 \pm 3.4	3 \pm 3.1	.601

Values shown are mean intakes

SD, standard deviation, kJ, Kilojoules, kcal, Kilocalories

N=1023

Significant differences between genders were examined using Independent t tests for continuous data.

[†] Significance was established as p <0.05 using parametric statistics

Table 6.4: Difference of energy, CHO and sugars intake according to body mass index categories

	Underweight (N=11)		Healthy Weight (N=740)		Overweight (N=195)		Obese (N=77)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	<i>P</i> †
Energy (kcal)	1603	151.4	1522	305.8	1545	296.5	1410	263.6	.066
Energy (kJ)	6723	648.8	6386	1283.7	6486	1241.4	5926	1115.2	.072
Carbohydrates (g)	216	16.1	204	43.7	208*	42.2	186*	50.4	.034
% CHO to total energy	54.37	6.64	53.66	5.61	54.03	4.9	52.8	8	.669
Total sugars (g)	111	17.7	95	30	98.3	30.7	89	40	.067
Free sugars (g)	69	17.8	48	22.1	51	23.7	46	33.8	.061
Fibre (AOAC)	13.5	2.1	13.6*	3.6	13	3.3	12*	3	.036

SD, standard deviation, kJ, Kilojoules, kcal, Kilocalories

Values shown are mean intakes

N=1023

A one way analysis of variance was used to determine the relationship between diet and BMI

† Significance was established as <0.05

* Indicates where the significance lies

Table 6.5: Difference of free sugar sources according to Body Mass Index categories.

	<u>Healthy weight (N=86)</u>		<u>Overweight (N=23)</u>		<u>Obese (N=16)</u>		
Free sugar groups	Mean	SD	Mean	SD	Mean	SD	P†
Sugar sweetened beverages	11	10.8	10.4	7.3	11.4	17.2	.959
Cereal and cereal products	6.3	5.3	6.5	4.7	4.2	4.4	.283
Confectionary	9.2	8.2	11.6	7.1	8	8.7	.324
Milk and milk products	6.7	6.9	9	8.6	5.3	3.9	.211

Values shown are mean intakes

SD, standard deviation, kJ, Kilojoules, kcal, Kilocalories

N=125

A one way analysis of variance was used to determine the relationship between free sugar intake and BMI

† Significance was established as <0.05

Table 6.6: Differences in free sugar sources based on gender

Free sugar sources (g)	Males (N=64)	Female (N=61)	<i>P</i> †
	<u>Mean (SD)</u>	<u>Mean (SD)</u>	
SSB	11 (11.5)	10.6 (11.07)	.327
Cereals	6.4 (5.6)	5.6 (4.5)	.885
Confectionary	9.8 (7.6)	9.1 (8.6)	.507
Milk	7.2 (7.5)	6.5 (6.4)	.553

SD, standard deviation, kJ, Kilojoules, kcal, Kilocalories

N=125

Values shown are mean intakes

Significant differences between genders were examined using Independent t tests

†Significance is established at <0.05

Table 6.7: Pearson Correlations between percentage of carbohydrates, total sugars, free sugars and fibre

	<u>% carbohydrates</u>		<u>% total sugars</u>		<u>% free sugars</u>	
Fibre (g)	.154	<.001	.133	<.001	-.103	.012

N=1023

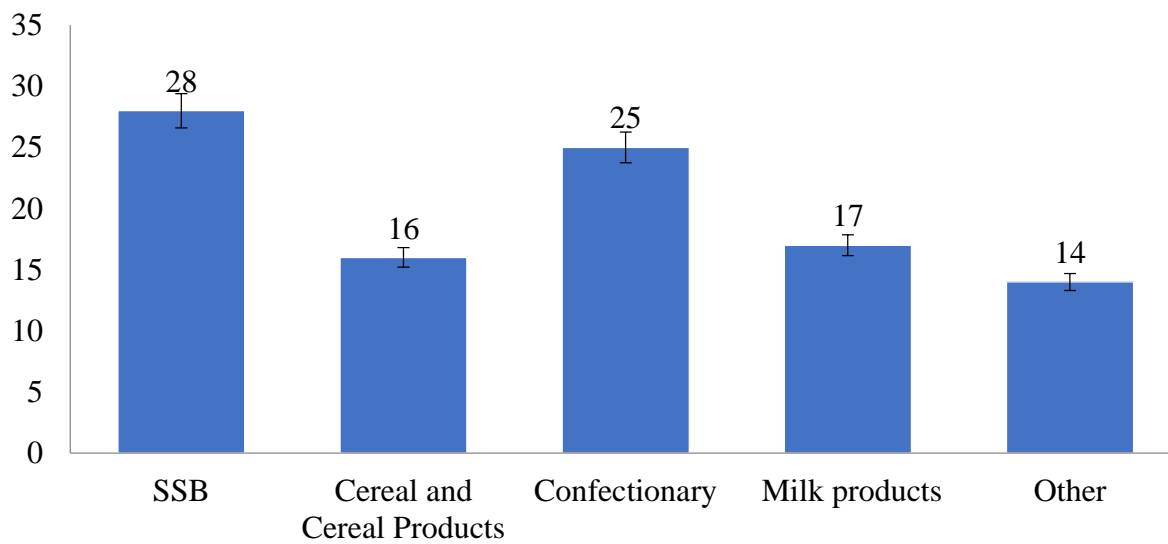
% Percentage of total energy

† Significance was established as <0.05

R value indicates the strength of the relationship

Fibre is represented by a mean intake

Figure 6.2: Percentage contribution of key food-groups to intakes of free sugars

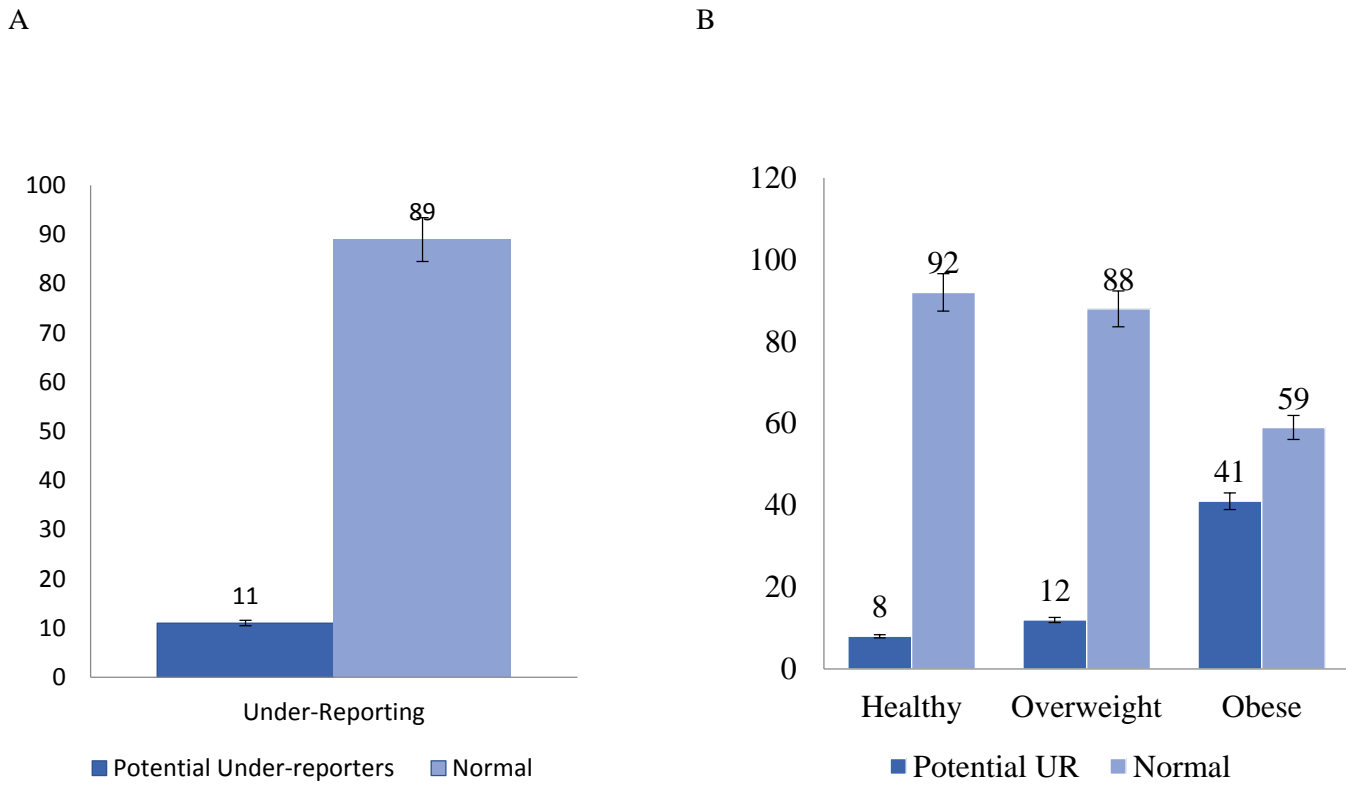


N=125

SSB, Sugar Sweetened Beverages

Values used are percentage contribution to free sugars

Figure 6.3: Percentage of under-reporters based on UK 90 BMI Z Scores



BMI, Body Mass Index

Under-reporting was determined using Energy Intake: Estimated Energy Expenditure (EI:EER) and the Goldberg cut-off point of <1.9 for potential under-reporters (Black 2000). Those above the cut-off point were presumed to have reported correctly.

- A) N=1023. The percentage of under-reporters in total group
- B) N=1023. The percentage of under-reporters within each BMI category determined using UK 90 BMI Z scores and Chi squared test

Chapter 7

General Discussion

Obesity is a major public health concern in the twenty first century (Seidell, 2000) as the prevalence has increased globally over recent years initially affecting the Western world, however now also increasingly in developing countries (Popkin, Adair and Ng, 2012).

The prevalence of overweight and obesity among children and adolescents aged 5-19 has risen from 4% in 1975 to approximately 20% in 2016 (WHO, 2017). The economic burden of obesity is increasingly impacting on healthcare costs and is thought to cost nearly 50 billion per year by 2050 (Morgan & Dent, 2010). Childhood obesity is a significant risk factor for adulthood obesity, and evidence suggests that up to 79% of children who are obese in their early teens, of which it is estimated that 70% will remain obese at 30 years of age (Simmonds et al., 2016). Furthermore they are at increased risk of developing serious health consequences including coronary heart disease, stroke and malignancy (Sahoo et al., 2015). As being overweight or obese is largely preventable, prevention needs to be of high public health priority (WHO, 2010).

Therefore, interventions aimed at reducing the prevalence of obesity should start at an early age and continued through different stages of the lifecycle throughout the later stages of life (Haslam and James, 2005). Evidence has also shown that the weight of a child at five-years-old is a good predictor of future weight and health status, having long-term effects on both mortality and morbidity (Dietz, 1998; Must & Strauss, 1999). Therefore, tackling obesity at an early age should be imperative as research has shown that childhood obesity is an accurate predictor of future morbidities such as diabetes, coronary heart disease, mental health issues and some types of cancer (Llewellyn et al., 2016). Furthermore, early onset of obesity occurring in childhood can lead to the development of metabolic syndrome as early as adolescence (Pacheco et al., 2017). Obesity is a multifactorial disease influenced by genetics, environmental, lifestyle and behavioural factors (Government Office for Science, 2007).

Whilst the genetic predisposition to childhood obesity is well documented, evidence reports that 90% of cases are owing to environmental influences (WHO, 2017). Children currently reside in an ‘obesogenic’ environment characterised by large portion sizes, increased availability and marketing of energy dense foods high in fat, salt and sugar (Barquera et al., 2018). This, in combination with physical inactivity favours energy imbalance and subsequent weight gain (Dev et al., 2013). In addition when teenagers leave home and move to university unhealthy eating behaviours may develop and has been recognised as a vulnerable period for the development of long-term health implications lasting well into adulthood. Many students struggle to adopt or maintain a healthy lifestyle as they become more independent, have limited budgets and are more influenced by new friends.

The overall aim of this thesis was to evaluate the nutritional and lifestyle factors which influence dietary habits focusing on childhood and young adults and in addition to investigate the use of social media in influencing dietary habits.

In order to address the aim of this PhD, a mixed methods approach was used. The main aims were addressed by undertaking a systematic review, conducting a focus group, running a randomised control trial and undertaking secondary analysis of dietary data collected as part of HAPO study to assess dietary intake in childhood. (Chapter 2). The systematic review in chapter 2 systematically evaluated the use of social network interventions used to prevent obesity among university students. This identified 6 studies (2125 university students) of which 2 showed significant BMI reduction in the intervention group as compared to the control group using social networks sites such as Facebook. Concluding that multicomponent interventions which include social networks may be potentially useful in helping university students to prevent obesity, however they did not include longer term follow up after the intervention ended (Chapter 2). This systematic review provided evidence that social network sites were

popular with students and therefore was used to design both the qualitative study (Chapter 3) and randomised controlled trial (Chapter 4).

Chapter 3 aimed to explore the eating behaviours and experiences of students attending university in Northern Ireland. This qualitative study recruited 42 local and international students to participate in facilitated focus group discussions designed to identify barriers to eating healthy and maintain acceptable BMI when living away from home. Three key themes were identified as influencing dietary choices and eating behaviours: *nutritional awareness and knowledge*, *personal factors* and *physical factors*. Students highlighted lack of nutritional knowledge in making healthy food choices as important, additionally they noted that cooking facilities available for storing and cooking food were problematic in accommodation, and also lack of time associated with academic deadlines for assessments. Students were very interested in learning more about healthy eating and were very supportive of providing more information for students. (Chapter 3). The focus group also highlighted that participants suggested the use of social networks to provide nutritional tips and information with photos such as Facebook as preferred method to deliver education for young adults.

Students were keen to receive information on these forums and reported that lectures and face to face methods were not favoured as a way to provide nutrition education.

Therefore based on results from systematic review and focus groups. A randomised control trial was designed using Facebook as a tool to provide education to students as a way of increasing FV intakes (Chapter 4). In addition provision of fruit and vegetables was chosen as there is strong evidence which has shown that diets of children and young adults is generally low in FV which contributes to poor nutritional intake. In addition students have limited budgets therefore unable to spend additional money to buy fruit and vegetables. Therefore an RCT was designed to test the effectiveness of using Facebook to deliver nutritional education

with regards increasing consumption and changing behaviour with regards fruit and vegetables consumption. The aims of this chapter (4) were 1) to deliver and evaluate a nutrition intervention aimed at increasing FV intakes of university students living away from home, 2) to investigate the impact of providing 5 portions of FV weekly on biomarkers of FV intakes in students living away from home and 3) to investigate whether FV consumption was further enhanced when FB messages providing nutritional education were also used. Sixty full time students were recruited from Coleraine campus and randomly assigned to one of three groups: *Control group* were asked to maintain their normal diet; *F&V group* received free of charge five portions of fruit and vegetables daily for 4 weeks based on individualised preferences; and *F&V + FB group* received FV (as for the F&V group) plus daily nutrition education messages with regards FV delivered via FB. Results showed that the provision of free fruit and vegetables increased consumption in both intervention groups from baseline to end of study, with 65% of participants consuming 5 portions of FV each day. However, inclusion of FB did not have any enhanced effect on FV consumption in the short term. As providing additional nutrition education support via FB was not successful at changing behaviour and did not enhance FV consumption Therefore this study demonstrated that provision of free fruit and vegetables aids change in behaviour with students increasing intake in the short term. Future studies should investigate other novel ways to encourage students to eat more fruit and vegetables at a reduced cost.

Chapter 5 and 6 investigates dietary intake in a cohort of children at approximately 6 years old in NI to provide baseline data on dietary intakes of young children of varying BMI. Both chapters use data from Hyperglycaemic and Adverse Pregnancy Outcome Study (HAPO 2008) an observational study which was designed to assess risk of developing metabolic syndrome. . Analysis of this data was undertaken as to support this PhD as strong evidence has shown that

the weight of a child at five-years-old is a good predictor of future weight and health status (Dietz, 1998; Must & Strauss 1999; Weng et al., 2012) and that dietary habits are established in early childhood and this could be an important stage in a child's life to influence dietary habits. Evidence suggests that obesity results when energy intake exceeds energy expenditure and that dietary composition and energy intake are important contributors to weight gain. A modern-shift in food intakes and eating habits which include an increase in the consumption of processed-food and sugar sweetened beverages (SSBs) with a decrease of fruits and vegetables, has also been linked to the increase of childhood obesity. However, no single factor has been determined the primary cause (Langley-Evans, 2015). Associations with dietary patterns (DPs), such as consumption of high-fat and/or sugary foods and low fruit and vegetable consumption, have also been associated with the development of obesity (Ambrosini et al., 2012; An, 2017). As different foods are eaten in combination and contain a variety of nutrients, it is thought that analysing diet and health outcomes through dietary patterns, which are statistically derived is valuable to describe an individual's diet as a whole as opposed to focusing on specific nutrients. Therefore gaining an understanding of the composition of children's diets is beneficial in providing baseline information to influencing dietary changes in young adults.

Chapter 5 used dietary patterns to identify patterns of food consumption in 6 year old children. This current study identified 3 dietary patterns: Processed, junk and healthy with all factor loadings. The first pattern identified was termed 'Processed' which loaded with high intake of meat products, grains and snack foods such as bacon, sausages, beef burgers, additionally, these children consumed more ice cream and fizzy drinks than average. This pattern reflects the processed diet high in fat and low in fibre and has been widely associated with the development of obesity epidemic in 1970s (Vang et al., 2008). Participants who were identified as having processed diets were found to have a lower intake of vitamin C and fibre. However, no

significant correlations of between the dietary pattern and BMI was found. Dietary pattern 2 called “*junk*”, had high positive loadings for sweets including chocolate and biscuits and crisps. This dietary pattern was significantly positively associated with weight, BMI, waist-to-height ratio, hip and mid-arm circumference, and showed that significant positive correlations were observed between scores for dietary pattern 2 (junk) and BMI z scores suggesting that children who consumed more sweets, chocolate, confectionary are at increased risk of having a higher BMI. Those who loaded for dietary pattern 3 ‘healthy’ had higher intakes of fruit and vegetables, wholemeal cereal products, such as brown rice, porridge and wholemeal pasta and bread and was positively correlated with intake of carbohydrates, proteins non-starch polysaccharides including fibre and various vitamins and micronutrients including vitamin C. Increased intake of dietary fibre has been found to be associated with around 10-20% decrease in energy intake and improved weight loss (Howarth, Saltzman and Roberts, 2001). The “*healthy*” diet was significantly positively associated with height of the participant children, which is consistent with the previously published research findings (Fewtrell et al., 1999) This current study therefore highlights overall better micronutrient profiles are associated with the ‘healthy’ patterns, opposed to the ‘processed.’ Higher consumption of fruits, vegetables, and unrefined-grains were more so associated with the healthier DPs with better nutrient profiles. This is consistent with literature that suggests the less healthy, or ‘processed’, DPs tended to have higher consumption of refined-grains, crisps, and sweets (Cribb et al., 2012). Evidence has shown that children who are introduced to either the ‘healthy’ or processed dietary pattern by age 7 years are likely to carry this diet into their adolescent years (Northstone et al., 2012). However evidence linking specific dietary patterns and excess adiposity in children is limited with evidence from clinical trials indicating only energy restriction, regardless of DP, is associated with better weight outcomes (Wadden et al., 2012).

Therefore these findings with regards dietary patterns suggest the need for investigating the contribution of free sugars and sugary foods in these diets to provide more detailed information on the types of sweet foods consumed and the overall contribution to their diet. Consumption of free sugars in excess of recommendations is strongly associated with obesity and low intakes of dietary fibre is an independent predictor of childhood obesity risk. Therefore Chapter 6 sought to primarily investigate the association between dietary carbohydrate intake and childhood obesity at 6 years and secondly, to investigate differences in dietary composition of children based on their Body Mass Index's (BMI's) and to identify the major sources of free sugars (FS's) and their contribution to FS intakes in children's diets.

Results indicate, a higher incidence of overweight and obesity amongst girls (32%) compared to boys (24%) at 6 years. However, boys were found to consumed more energy than girls overall and had a higher intake of carbohydrates, total sugars, free sugars, and total fat which is similar to the latest NDNS data, reporting a mean energy intake of 6.4 and 5.9 MJ for boys and girls age 5-10 (Public Health England, 2014). In the current study (Chapter 6), 12.6 % of total energy was derived from free sugars, exceeding the current recommendations of 10%. No relationship was observed in total sugars or free sugars between BMI categories in this current study. Although it was estimated that free sugar intake comprised 12.6% of total energy intake, the excess energy leading to weight increase can come from other dietary sources, such as cereal or dairy products. Nevertheless, these other energy sources often contain essential micronutrients which may be promote healthy energy metabolism. In this current study (Chapter 6), the highest intake was sugar sweetened beverages, second largest source of free sugars was confectionary which made up 25% of free sugar intake.

Obese children were found to consume less carbohydrate than the overweight group. However, these discrepancies could be explained by underreporting which is commonly reported in self-reported dietary surveys (Kye et al., 2014). Furthermore, it was found that normal weight children have a higher intake of dietary fibre, when compared to obese children. This supports findings in chapter 5 which identified a 'healthy' pattern and diets were higher in dietary fibre intake with healthy body weight.

Key areas identified by research conducted as part of this PhD which may have new information this thesis added to the literature have implications for researchers, policy makers, and practitioners involved in the promotion for healthy eating and preventing obesity in young adults and children are mentioned below:

In summary, the research presented in this thesis provides evidence to literature that:

- Social networks are useful as part of multi component interventions in achieving sustainable weight loss and changing in dietary patterns, however, when social networks were used individually, they had limited effectiveness in changing dietary behaviours.
- Main themes identified as influencing students eating habits when living away from home were: *nutritional awareness and knowledge, personal factors and physical factors.*

- Provision of free fruit and vegetables to students increased consumption with 65% of participants eating 5 portions each day during the intervention. However, Facebook was not effective and did not further enhance the intake of FV.
- Dietary assessment using principle component analysis identified 3 dietary patterns: processed, junk and healthy. In addition children who consumed 'junk dietary pattern' had higher BMI than those consuming healthy and processed dietary patterns.
- Sugar-sweetened beverages were identified as the major source of FS's followed by confectionary, contributing on average to 28% and 20% to FS intakes, respectively in the diets of 6 year olds. However this study did not provide evidence that dietary carbohydrates including free sugars increased the risk of childhood obesity.

There is potential for future work arising from this thesis:

- Further randomised trials in students are warranted with the use of different popular platforms for example ‘snapchat’ or YouTube to confirm these findings.
- Provision of free or reduced price fruit to students and children and encourage variety and inclusion in diet.
- Peers have an important influence and would be useful to explore in more detail in future with respect dietary habits.
- Promotion of healthy eating as part of induction of new /freshmen university students to influence behaviours early

Limitations of the thesis

Engagement with FB dropped as the intervention progressed therefore a different platform may have encouraged participation and in addition a different format of nutritional tips for example pictures may have encouraged participation. Running the intervention in semester 1 may have been more beneficial as the timing of the follow-up intervention and measurements (semester 2 weeks 9, 10, 11) may have impacted on the adherence to the intervention. These interventions and measurements were conducted during Easter vacation and at the end of the academic year, when participants are submitting coursework and preparing to undertake final exams. . Although increased levels of stress due to the examination period in the time of follow-

up might have had a confounding effect, future effective intervention should consider the impact of such these barriers and include maintenance component to achieve sustainable reduction in body weight and eating behaviours. Another limitation associated with the study is the possibility of underreporting or overestimation of dietary intake. Data was collected using a self-reported food semi quantitative food frequency questionnaire which may have resulted in under or over reporting of diet consumed. Evidence proposes that overweight and obese individuals are likely to underreport on unhealthy diet which may directly influence their overall dietary intake. Therefore this limitation should be considered when interpreting these results and identified as an area for further research.

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Appendix 1 Confirmation of ethical approval (Chapter 3 and 4)

Memo

To: Dr A Hill, W2071, School of Biomedical Sciences,
Coleraine

From: Elaine McCormick, Research Governance, 26A17,
Jordanstown

Date: 24 October 2016 **Ref:**

Ulster University

Research Ethics Committee

Project Number: REC/16/0097

**Project Title: Increasing fruit and vegetable consumption in University
students: A randomised controlled study**

**Outcome: Approved to proceed subject to amendment to be considered by a UREC
sub-committee**

Please find attached the comments of the Research Ethics Committee on your recent application.

You should address these comments point by point in a covering letter and highlight or underline any revisions made to the application and associated materials. Please send your response by e-mail to e.mccormick@ulster.ac.uk. Your response will then be referred to members of a sub-committee for comment. You should note that your application does not require to be resubmitted for reconsideration at a future meeting, but you should also note that you cannot commence any research on human subjects until your response has been considered and a letter of approval has been issued.

Please note that all Ulster staff and student members of the research team must provide evidence that they have successfully completed the University's online Research Integrity course. Final approval for the study will not be confirmed until this has been provided.

If you have any queries, please contact Nick Curry or Elaine McCormick.

If you do not intend to proceed with the project or if you anticipate a significant delay in responding to the concerns of the committee, please contact the Research Governance section.

I look forward to hearing from you in the near future. Please quote the **Project Number** in all correspondence.

Thank you and best wishes.

Elaine McCormick

Admin Officer

Research Governance

e.mccormick@ulster.ac.uk

Ext: 66518

UNIVERSITY OF ULSTER
GOVERNANCE

RESEARCH

RG3 Filter Committee Report Form

FCBMS-16-056

Project Title Nutrition education using Facebook to increase fruit and vegetable consumption: a randomised controlled study

Chief Investigator Dr Alyson Hill

Filter Committee Biomedical Sciences

This form should be completed by Filter Committees for all research project applications in categories A to D (*for categories A, B, and D the University's own application form – RG1a and RG1b – will have been submitted; for category C, the national, or ORECNI, application form will have been submitted).

Where substantial changes are required the Filter Committee should return an application to the Chief Investigator for clarification/amendment; the Filter Committee can reject an application if it is thought to be unethical, inappropriate, incomplete or not valid/viable.

Only when satisfied that its requirements have been met in full and any amendments are complete, the Filter Committee should make one of the following recommendations:

The research proposal is complete, of an appropriate standard and is in

- category A and the study may proceed* ☒

- category B and the study must be submitted to the University's Research Ethics Committee** Please indicate briefly the reason(s) for this categorisation ☐

- category C and the study must be submitted to ORECNI along with the necessary supporting materials from the Research Governance Section*** ☐

- category D and the study must be submitted to the University's Research Ethics Committee** ☐

All points below have now been addressed satisfactorily.

Signed: 

Date: 26/09/16

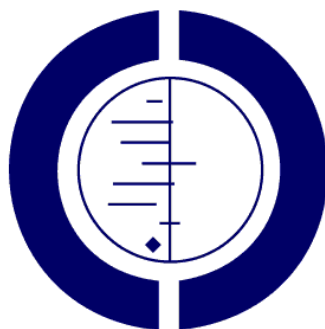
***The application form and this assessment should now be returned to the Chief Investigator. The Filter Committee should retain a copy of the complete set of forms.**

**** The application form and this assessment should now be returned to the Chief Investigator so that he/she can submit the application to the UUREC via the Research Governance section. The Filter Committee should retain a copy of the complete set of forms for their own records.**

***** The application form and this assessment should now be returned to the Chief Investigator so that he/she can prepare for application to a NRES/ORECNI committee. The Filter Committee should retain a copy of the complete set of forms for their own records.**

For all categories, details of the application and review outcome should be minuted using the agreed format and forwarded to the Research Governance section

Appendix 2 supplementary materials for systematic review and data extraction



The Cochrane Public Health Group

Data Extraction and Assessment Template

This form suggests elements which should be addressed in your review and is to be modified in keeping with the following instructions. Some questions may be changed from open-ended questions to specific data items where appropriate. Refer to the Cochrane Handbook when undertaking modifications to this form.

Sections can be expanded and irrelevant sections can be removed. It is difficult to design a single form that meets the needs of all reviews. It is therefore important that you consider your needs carefully prior to data extraction and pilot your process. Elements within the template are not intended for use as a scoring system. The components of the *Risk of Bias Table* have been incorporated into this form. Criteria for judging risk of bias as well as examples of appropriate methods of addressing each form of bias are provided in Chapter 8 of the Cochrane Handbook, particularly Table 8.5.c. For tips on how to enter data into RevMan 5, see “Risk of Bias” tables in the RevMan User Guide. If you are using an additional quality assessment tool you will need to add appropriate questions to reflect the additional components.

Cochrane Public Health Group Data Extraction and Assessment Template (*modify* to suit your review)

Study ID:	Report ID :	Date form completed:
First author:	Year of study:	Data extractor:
Citation:		

1. General Information

Publication type	Journal Article <input type="checkbox"/> Abstract <input type="checkbox"/> Other (specify e.g. book chapter) _____
Country of study:	
Funding source of study:	Potential conflict of interest from funding? Y / N / unclear

2. Study Eligibility

Study Characteristics			Page/ Para/ Figure #
Type of study (Review authors to add/remove designs based on criteria specified in protocol)	<input type="checkbox"/> Randomised Controlled Trial (RCT) <input type="checkbox"/> Cluster Randomised Controlled Trial (cluster RCT)	<input type="checkbox"/> Controlled Before and After (CBA) study <ul style="list-style-type: none"> • Contemporaneous data collection • Comparable control site • At least 2 x intervention and 2 x control clusters 	
	<input type="checkbox"/> Interrupted Time Series (ITS) <ul style="list-style-type: none"> • At least 3 time points before and 3 after the intervention • Clearly defined intervention point 	<input type="checkbox"/> Other design (specify):	
	<input type="checkbox"/> A process evaluation of an included study design	<i>Does the study design meet the criteria for inclusion?</i> Yes <input type="checkbox"/> No <input type="checkbox"/> → Exclude Unclear <input type="checkbox"/>	

	Description in text:		
Participants (Review authors insert inclusion criteria as defined in Protocol)	Describe the participants included:		
	Are participants defined as a group having specific social or cultural characteristics?	Yes <input type="checkbox"/> No <input type="checkbox"/> Unclear <input type="checkbox"/> Details:	
	How is the geographic boundary defined?	Details: Specific location (e.g. state / country):	
	<i>Do the participants meet the criteria for inclusion?</i>	Yes <input type="checkbox"/> No <input type="checkbox"/> → Exclude Unclear <input type="checkbox"/>	

Types of intervention (Review authors insert inclusion criteria as defined in Protocol)	Strategies included in the intervention		
	Focus of the intervention		
	<i>Does the intervention meet the criteria for inclusion?</i>	Yes <input type="checkbox"/> No <input type="checkbox"/> → Exclude Unclear <input type="checkbox"/>	
Duration of intervention	Start date:	Stop date:	Intervention duration:
	<i>Is the duration of intervention adequate for inclusion?</i>		Yes <input type="checkbox"/> No <input type="checkbox"/> → Exclude Unclear <input type="checkbox"/>
Types of outcome measures (Review authors insert inclusion criteria as	List outcomes:		
	Outcome measured at a population level or individual level?		Details:
	<i>Do the outcome measures meet the criteria for inclusion?</i>		Yes <input type="checkbox"/> No <input type="checkbox"/> → Exclude Unclear <input type="checkbox"/>

defined in Protocol)			
-------------------------	--	--	--

Summary of Assessment for Inclusion

Include in review <input type="checkbox"/>		Exclude from review <input type="checkbox"/>	
Independently assessed, and then compared? Yes <input type="checkbox"/> No <input type="checkbox"/>		Differences resolved Yes <input type="checkbox"/> No <input type="checkbox"/>	
Request further details? Yes <input type="checkbox"/> No <input type="checkbox"/>		Contact details of authors:	
Notes:			

DO NOT PROCEED IF PAPER EXCLUDED FROM REVIEW

3. Study details

Study intention	Descriptions as stated in the report/paper	Page/ Para/ Figure #
Aim of intervention	<i>What was the problem that this intervention was designed to address?</i>	
Aim of study	<i>What was the study designed to assess? Are these clearly stated?</i>	
Equity pointer: Social context of the study	<i>e.g. was study conducted in a particular setting that might target/exclude specific population s? See also Inclusion/exclusion criteria under Methods, below.</i>	
Start and end date of the study	<i>Identify which elements of planning of the intervention should be included</i>	

Total study duration		
----------------------	--	--

Methods	Descriptions as stated in the report/paper	Page/ Para/ Figure #
Method/s of recruitment of participants <i>(How were potential participants approached and invited to participate? Where were participants recruited from? Does this differ from the intervention setting?)</i>		
Inclusion/exclusion criteria for participation in study		
Representativeness of sample: Are participants in the study likely to be representative of the target population?		
Total number of intervention groups		
Assumed risk estimate <i>(e. .baseline or population risk noted in Background)</i>	References:	
Sample size calculation: What assumptions were made? Were these assumptions appropriate?	 <i>(Yes/No/Unclear)</i>	
What was the unit of randomisation? Allocation by individuals or cluster/groups		
What was the unit of analysis? Is this the same as the unit of randomisation?	 <i>(Yes/No/Unclear)</i>	

Statistical methods used and appropriateness of these methods	(Check with your statistician if unsure about appropriateness)	
---	--	--

Results

Participants <i>Include if relevant</i>	Include information for each group (i.e. intervention and controls) under study	Page/ Para/ Figure #
<ul style="list-style-type: none"> What percentage of selected individuals agreed to participate? 		
<ul style="list-style-type: none"> Total number randomised (or total pop. at start of study for NRCTs) 		
<ul style="list-style-type: none"> Number allocated to each intervention group (no. of individuals) 		
<ul style="list-style-type: none"> For cluster trials, number of clusters, number of people per cluster 		
<ul style="list-style-type: none"> Where there any significant baseline imbalances? 	Yes <input type="checkbox"/> No <input type="checkbox"/> Unclear <input type="checkbox"/> Details:	
<ul style="list-style-type: none"> Number and reason for (and sociodemographic differences of) withdrawals and exclusions for each intervention group 		
<ul style="list-style-type: none"> Were patients who entered the study adequately accounted for? 		
<ul style="list-style-type: none"> What percentage of patients completed the study? 		
<ul style="list-style-type: none"> What percentage of participants received the allocated intervention or exposure of interest? 		
<ul style="list-style-type: none"> Is the analysis performed by intervention allocation status 		

(intention to treat) rather than the actual intervention received? Have any attempts been made to impute missing data?		
• Age (median, mean and range if possible)		
• Sex		
• Race/Ethnicity		
• Principal health problem (incl. stage of illness)		
• Diagnostic criteria		
• Co-morbidity		
• Other sociodemographics (eg. Educational level, literacy level, soci-economic status, first language. Also consider possible proxies for these e.g. low baseline nutritional status)		
• PROGRESS categories reported at baseline (indicate letters of those reported: Place of residence, race, occupation, gender, religion, education, SES, social capital)		
Subgroups	<i>Enter a description of any participant subgroups from this paper to be analysed in the review.</i>	

Intervention Group 1*(copy and paste table for each Intervention group)*

Group name:	<i>(State brief name for this intervention group.)</i>	Page/ Para/ Figure #
Details of intervention or control condition <i>(Include if relevant in sufficient detail for replication)</i>		
<ul style="list-style-type: none"> Setting eg multicentre, university teaching hospitals, rural, metropolitan, school, workplace, community, GP clinic, etc. 		
<ul style="list-style-type: none"> Theoretical basis (include key references) 		
<ul style="list-style-type: none"> Content (list the strategies intended and delivered) 		
<ul style="list-style-type: none"> Did the intervention include strategies to address diversity/disadvantage? 	<i>Enter a description of any relevant strategies</i>	
<ul style="list-style-type: none"> Delivery (eg. Stages (sequential or simultaneous), timing, frequency, duration, intensity, fidelity – process indicators) 		
<ul style="list-style-type: none"> Providers (who, number, education/training in intervention delivery, ethnicity etc. if potentially relevant to acceptance and uptake by participants) 		
<ul style="list-style-type: none"> Co-interventions 		
Duration of intervention		
Duration of follow-up		

Was sustainability discussed by the authors? Was is a consideration in study development?		
Economic variables ie costs of the intervention, and changes in other (eg health care) costs as result of intervention [▲]	Yes <input type="checkbox"/> → List in Outcome section if appropriate No <input type="checkbox"/> Unclear <input type="checkbox"/> Details:	
Other economic information (from a societal, non-healthcare view – e.g. lost wages, time)	Yes <input type="checkbox"/> No <input type="checkbox"/> Details:	
Resource requirements to replicate intervention (e.g. staff numbers, hours of implementation, equipment?)		
Subgroups	<i>Enter a description of any intervention subgroups from this report to be analysed in the review.</i>	
What are the moderators/mediators of changes stated in the study?		
Do the authors describe any political or organisational context?	<i>List relevant dot points</i>	
Were any partnerships referred to?	<i>List these as dot points</i>	
Was a process evaluation conducted?	<i>What components were included in the process evaluation? (eg. dose, frequency, consistency, implemented as intended etc)</i>	
Control/comparison (what information is provided about what the control or comparison group received?)	<i>Enter a description of what was provided for the control group, if applicable</i>	

[▲] Costs associated with the intervention can be linked with provider or participant outcomes in an economic evaluation (depends on the type of economic evaluation)

Outcomes

(This table is set up for 2 outcome measure to save spaces, copy and paste table as often as required)

Question	Outcome 1	Page/ Para/ Figure #	Outcome 2	Page/ Para/ Figure #
Is there an analytic framework applied (e.g. logic model, conceptual framework)?				
Outcome definition (with diagnostic criteria if relevant)				
Type of outcome: Is this a modifiable variable (Community level, neighbourhood level, individual level) or desired health outcome				
Time points measured				
Time points reported				
Is there adequate latency for the outcome to be observed?				
Is the measure repeated on the same individuals or redrawn from the population / community for each time point?				

Unit of measurement (if relevant)				
For scales – upper and lower limits and indicate whether high or low score is good				
How is the measure applied? Telephone survey, mail survey, in person by trained assessor, routinely collected data, other				
How is the outcome reported? Self or study assessor				
Is this outcome/tool validated?				
...And has it been used as validated?				
Is it a reliable outcome measure?				
Is there adequate power for this outcome?				
Were PROGRESS categories analysed by outcome? Indicate the letters of those that outcomes were analysed by (place of residence, race,				

occupation, gender, religion, education, SES, social capital)				
---	--	--	--	--

Results

Copy and paste the appropriate table for each outcome and subgroup at each timepoint, including baseline

For RCT/CCT

Dichotomous outcome

page/para/fig

Comparison					
Outcome					
Subgroup					
Timepoint					
Results	Intervention		Comparison		
	Events	No. participants	Events	No. participants	
No. of missing participants and reasons					
Any other results reported					
Reanalysis required? (specify - (e.g. correlation adjustment)					

Reanalysis possible?	<i>yes/no/unclear</i>	
Reanalysed results		

For RCT/CCT**Continuous outcome**

page/para/fig

Comparison							
Outcome							
Subgroup							
Timepoint							
Post-intervention or change from baseline?							
Results	Intervention			Comparison			
	Mean	SD (or other variance)	No. participants	Mean	SD (or other variance)	No. participants	
No. missing participants and reasons							
Any other results reported							

Reanalysis required? (specify)		
Reanalysis possible?	<i>yes/no/unclear</i>	
Reanalysed results		

For RCT/CCT

Generic inverse variance method

Page/para/figure

Comparison					
Outcome					
Subgroup					
Timepoint					
Results	Effect estimate	SE (or other variance)	Intervention no.	Control no.	
No. missing participants and reasons					
Any other results reported					
Reanalysis required? (specify)					
Reanalysis possible?	<i>yes/no/unclear</i>				

Reanalysed results		
--------------------	--	--

Risk of bias assessment

Please refer to Chapter 8 - *Table 8.5.c: Criteria for judging risk of bias in the 'Risk of bias' assessment tool* and to the *Cochrane EPOC Group's guidance for assessing Risk of bias for studies with a separate control group (RCTs, CCTs, CBAs) and Risk of bias for interrupted time series studies* (Appendix 3) for additional guidance for scoring Yes/No/Unclear. Note that the table below includes items from both EPOC tools. The ITS tool has been incorporated into the bottom of the table and all items for ITS studies are denoted by ITS preceding the risk of bias question.

Domain	Review authors' judgement*	Description	Page/ Para/ Figure #
Was the allocation sequence adequately generated?	Yes / No / Unclear	<i>Describe the method used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups.</i>	
Was allocation adequately concealed?	Yes / No / Unclear	<i>Describe the method used to conceal the allocation sequence in sufficient detail to determine whether intervention allocations could have been foreseen in advance of, or during, enrolment.</i>	
Were baseline outcome measurements similar?	Yes/No/Unclear	<i>Note whether baseline outcome measurements were reported and whether there were any important differences between groups. If there were important differences between groups, note whether appropriate adjusted analysis was performed to account for this.</i>	
Were baseline characteristics similar?	Yes/No/Unclear	<i>Note whether baseline characteristics were reported and whether there were any important differences between groups.</i>	
Were incomplete outcome data adequately addressed?	Yes / No / Unclear	<i>Describe the completeness of outcome data for each main outcome, including attrition and exclusions from the analysis. State whether attrition and exclusions were reported, the numbers in each intervention group (compared with total randomized participants),</i>	

Assessments should be made for each main outcome (or class of outcomes).		reasons for attrition/exclusions where reported, and any re-inclusions in analyses performed by the review authors.	
<p>Was knowledge of the allocated intervention adequately prevented during the study?</p> <p>Separate assessments should be made for relevant groups of people involved in the study i.e participants, outcome assessors, investigators, data assessors etc</p>	Yes / No / Unclear	<p>Describe all measures used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective, or whether blinding was appropriate.</p> <ul style="list-style-type: none"> • Participants – yes, no, unclear [record supporting statement from study]. • Investigators – yes, no, unclear [record supporting statement from study]. • Outcomes assessors – yes, no, unclear [record supporting statement from study]. <p>Data assessors – yes, no, unclear [record supporting statement from study].</p>	
Was the study adequately protected against contamination?	Yes/No/Unclear	State whether and how the possibility of contamination was minimised by the study design/implementation.	
<p>Are reports of the study free of suggestion of selective outcome reporting?</p> <p>Assessments should be made for each</p>	Yes / No / Unclear	State how the possibility of selective outcome reporting was examined by the review authors, and what was found.	

<i>main outcome (or class of outcomes).</i>			
Other sources of bias •	Yes / No / Unclear	<i>State any important concerns about bias not addressed in the other domains in the tool.</i>	
ITS: Was the intervention independent of other changes?	Yes/No/Unclear	<i>Describe whether or not the intervention occurred independently of other changes over time and whether or not the outcomes may have been influenced by other confounding variables/historic events during the study period.</i>	
ITS: Was the shape of the intervention effect pre-specified?	Yes/No/Unclear	<i>State whether or not the point of analysis was the point of intervention. If not, describe whether a rationale for the shape of the intervention effect was given by the study authors.</i>	
ITS: Was the intervention unlikely to affect data collection?	Yes/No/Unclear	<i>Describe whether or not the intervention was likely to affect data collection and what the potential impact might have been.</i>	

<p>ITS: Was knowledge of the allocated interventions adequately prevented during the study?</p> <p><i>Separate assessments should be made for relevant groups of people involved in the study i.e participants, outcome assessors, investigators, data assessors etc</i></p>	<p>Yes/No/Unclear</p>	<p><i>Describe all measures used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective, or whether blinding was appropriate.</i></p> <ul style="list-style-type: none"> • Participants – yes, no, unclear <i>[record supporting statement from study]</i>. • Investigators – yes, no, unclear <i>[record supporting statement from study]</i>. • Outcomes assessors – yes, no, unclear <i>[record supporting statement from study]</i>. <p>Data assessors – yes, no, unclear <i>[record supporting statement from study]</i>.</p>	
<p>ITS: Was incomplete outcome data adequately addressed?</p> <p><i>Assessments should be made for each main outcome (or class of outcomes).</i></p>	<p>Yes/No/Unclear</p>	<p><i>Describe the completeness of outcome data for each main outcome, including attrition and exclusions from the analysis. State whether attrition and exclusions were reported, the numbers in each intervention group (compared with total randomized participants), reasons for attrition/exclusions where reported, and any re-inclusions in analyses performed by the review authors.</i></p>	
<p>ITS: Was the study free from selective reporting?</p>	<p>Yes/No/Unclear</p>	<p><i>State how the possibility of selective outcome reporting was examined by the review authors, and what was found.</i></p>	

ITS: Was the study free from other risks of bias?	Yes/No/Unclear	State any important concerns about bias not addressed in the other domains in the tool.	
---	----------------	---	--

* Note: For each section above 'Yes' indicates a 'low risk of bias'; 'No' indicates a 'high risk of bias'; 'Unclear' indicates an 'uncertain risk of bias'. When entering the data into RevMan, the options to choose from will be 'Low', 'High' and 'Unclear'

Results

Comparison: _____

Outcome: _____

Subcategory: _____

Treatment group:		Control group:	
Observed (n)	total (N)	observed (n)	total (N)

	Treatment group:	Control group:
Total randomised		
excluded*		
Observed		
lost to follow up*		

*Reasons for loss/exclusion:

Subcategory: _____

Treatment group:		Control group:	
Observed (n)	total (N)	observed (n)	total (N)

	Treatment group:	Control group:
Total randomised		
excluded*		
Observed		
lost to follow up*		

*Reasons for loss/exclusion

Electronic Supplementary Material, Table S1

Internet and Social Networking related MeSH:	
<ul style="list-style-type: none"> -Blogging -Social media -Local area networks -computer communication networks -exp internet 	<p>Inclusion criteria</p> <p>Information, videos, consulting and massaging through social network sites and Interventions using network alone or as part of a complex intervention</p>
AND Internet and Social Networking as keyword because no Mesh:	
<ul style="list-style-type: none"> - "Social Network*" - "Social media" - Facebook - blog* or - Googl* or - microblog* or -myspace or -podcast* or -tweet* or -snapchat or -whatsapp or -Electronic Mail* or -instagram or -periscope or -blackboard or -e-health or -chat* or -Health 2.0 or - Medicine 2 or 	<p>Inclusion criteria</p> <p>Information, videos, consulting and massaging through social network sites and Interventions using network alone or as part of a complex intervention</p>
AND Promotion terms	
<ul style="list-style-type: none"> -Exp attitude to health/ or health knowledge, attitudes, practice or -Health Education or -behavio?r* or -communicat* or -educat* or 	<p>Inclusion criteria</p> <p>Change of lifestyle behaviours, weight loss and healthy eating habits</p>

-promot* or -enhance* or	
AND Nutritional terms	
exp Diet or -diet* or -nutrition* or -food* or -weight* or -Body Weight or Body Weight Maintenance/ or Weight Gain/ or Ideal Body Weight	Inclusion criteria Change of lifestyle behaviours, weight loss and healthy eating habits
AND Target group terms as keyword	
-Students or -Universities or -("college student*" or "university student*")	

Electronic Supplementary Material, Table 1

Appendix 3 Questionnaires Chapter 3

Screening questionnaire

To explore experiences which influence eating behaviours when living away from home

My name is Amin Hafiz, a PhD student in Human Nutrition based within NICHE Ulster University. I am undertaking research using focus group to discuss experiences influencing eating behaviours when regularly living away from home. If you are interested in participating in focus group, please complete this short questionnaire. All responses are anonymous and will only be used for the purposes of this research study.

If you would like any further information regarding this study please contact me by email (Hafiz-A2@email.ulster.uk) or my supervisors Dr Alyson Hill (aj.hill@ulster.ac.uk) and Prof Alison Gallagher (am.gallagher@ulster.ac.uk)

1: What is your age?

_____ years

2: What best describes your living arrangements?

Living with own family ☐

Living in Single accommodation ☐

Living in Shared accommodation ☐

Other _____

3: Do you regularly live away from home for 4 or more nights during each week of semester?

Yes ☐

NO ☐

4: Which campus are you attending?

Coleraine ☐

Belfast ☐

Jordanstown

Magee.

5: If you would like to participate in a focus group, please complete your contact details and I will arrange a suitable date and campus of your choice:

Mr Amin Hafiz

Email: Hafiz-A2@email.ulster.ac.uk

Contact phone number: 07454925559

CLICK SUBMIT

Thank you for taking part in this survey

To explore experiences which influence eating behaviours when living away from home: Focus group

Background information (to be collected as part of focus group)

My name is Amin Hafiz, a PhD student in Human Nutrition based within NICHE Ulster University. I am undertaking research using focus group to discuss experiences influencing eating behaviours when regularly living away from home. Please complete this short questionnaire. All responses are anonymous and will only be used for the purposes of this research study.

If you would like any further information regarding this study please contact me by email (Hafiz-A2@email.ulster.uk) or my supervisors Dr Alyson Hill (aj.hill@ulster.ac.uk) and Prof Alison Gallagher (am.gallagher@ulster.ac.uk)

1: What is your age?

_____ years

2: What is your gender?

Male ☐

Female ☐

3: What is your nationality?

British/Irish/UK ☐

Other European ☐

Non-European ☐

4: What degree of study are you in?

Year	BSc	PG/MSc/PhD
First		
Second		
Third		
Fourth		

5: What is the title of the course you are studying?

6: What is your current weight?

_____kg

7: What is your current height?

_____cm

**ULSTER UNIVERSITY
GOVERNANCE**

RESEARCH

Consent Form for studies involving the use of human tissue

Title of Study

A qualitative study to explore the experiences of university students which influence eating behaviours when living away from home

Chief Investigator

Dr Alyson Hill

Please confirm, by initialling the boxes provided, that you agree with the following statements:

1. I have been given and have read and understood the information sheet for the above study and have asked and received answers to any questions raised.

☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without my rights being affected in any way.

☐

3. I understand that the researchers will hold all information and data collected during the study securely and in confidence and that all efforts will be made to ensure that I cannot be identified as a participant in the study (except as might be required by law) and I give permission for the researchers to hold relevant personal data and also I give permission for the researchers to hold relevant personal data.

☐

4. I give permission to record the focus group discussions to be used for the purposes of this research study.

☐

5. I agree to take part in the above study and consent to my data being used for the purposes of this research study as outlined in the information sheet.

☐

6. If you would like to be kept informed about the research presentations / publications arising from this research please indicate this on your consent form and we'll let you know in due course.

☐

Name of Participant (please print)

Signature

Date (dd/mm/yy)

Name of person taking consent (if
different from researcher)

Signature

Date (dd/mm/yy)

Name of Researcher

Signature

Date (dd/mm/yy)



Participant Information Sheet

A Focus group study to explore the experiences of university students which influence eating behaviours when living away from home.

Invitation

You are being invited to take part in research at Ulster University as part of a PhD study. Before you decide whether or not to participate in the project, it is important that you understand why the research is being done and what it will involve. Please read the following information carefully and do not hesitate to ask any questions about anything that is unclear. Take some time to consider whether or not you wish to take part.

Thank you for your time.

What is the purpose of the study?

The transition from school to University has been recognised as a vulnerable period for development of overweight and obesity with males and females reportedly gaining between 3 and 4.4 kg during the first year. Many students face difficulties with maintaining or adapting to a healthy lifestyle resulting from living away from home, with more freedom, meeting new friends and peers, managing their own finances and adverse weight-related behaviours (e.g. poor dietary intake, inactivity) that are highly prevalent on university campuses. Factors reported as negatively impacting on healthy eating behaviours include limited availability of inexpensive healthy food, limited food choices, inadequate cooking skills and/or facilities to store and cook food which can lead to consumption of processed and ready meals and snacks. Likewise increased consumption of energy dense, high-fat foods is reported at times of stress and when finances are limited. Recent evidence from surveys of students both in USA and UK have concluded that the typical university student's diet is generally low in vegetables, fruits, and dairy products and usually high in fat, and sugar which leads to poor nutritional intake and weight gain leading to development of obesity. Thus, dietary behaviours of students may have major long-term health implications lasting into adulthood. Hence, further research is required to investigate the determinants of eating behaviours among university students in NI. The aim of this study is to explore your experiences which influence your eating behaviour during the academic year when living away from home. This valuable information will help inform future research work aimed at enhancing the diet quality of students whilst attending university.

Why have I been chosen?

You are being invited to take part in a focus group because you expressed interest (by responding to the recruitment email) in contributing further to this study. Also because you have met the inclusion criteria : 18 years old or over, male or female, currently registered as full time student at the Ulster University, living away from home, European and non-European student, undergraduate and postgraduate student in any university study disciplines /subjects.

Do I have to take part?

It is entirely voluntary and up to you whether or not to take part. If you do decide to take part, you will be given this information sheet to keep. You will also be asked to sign a consent form. If you choose to take part, you can change your mind at any time and withdraw from the study without giving a reason.

What will happen to me if I take part? And what is the focus group?

A focus group is a group of 8-10 students who have agreed to participate in a discussion to provide feedback on this study. The focus group will be a guided discussion between the student researcher and a group of undergraduate or postgraduate students from your campus. The discussion will last approximately between 1-1.5 hours. The topics discussed will include the following: has your diet habits changed since coming to the university, has your lifestyle habits changed in relation to alcohol or weight. The conversation during the focus group will be recorded to be used for the results and purposes of this research study. Your name during the discussion will be anonyms from the results of the study. However, only the research student will know the names of the participants in order to conduct the data analysis and match the responses with the participants. All personal information and transcripts collected will be anonymous as each participant will be given a unique ID number which will match the background data to the participant. An observer (a researcher) will sit in all focus groups and record appropriate anonymous conversation to permit relevant information to be linked to background data and this will provide quality assurance of anonymised data. All the recorded discussion and information during the focus group will be kept safe and will not reveal any opinions or data for instance age to others except only for named researchers.

Risks and/or disadvantages?

Whilst you may be asked to answer questions on related behaviours, all information provided by you will be kept confidential at all times. All responses to our questions and information provided by you will be anonymised. Only members of the research team will have access to the information you provide to us.

Are there any possible benefits in taking part?

We hope the information you will provide can help inform future research work aimed at enhancing the diet quality of students whilst attending university. Whilst there may be no personal benefits to your participation in this study.

What if new information becomes available?

Sometimes during the course of a research project, new information becomes available about the procedure that is being studied. If this happens, you will be told if there is any cause for concern and if you decide to withdraw you can do so without any explanation. If you decide to continue in the study you will be asked to sign an updated consent form.

What happens when the study ends?

The results of this study will help inform future research work aimed at enhancing the diet quality of students whilst attending university. The research will also be written up and

presented in a number of forms, both within the University (e.g. research presentations in the departments in which the research has been carried out) and to the national/international teaching and research community. The writing-up and presentations will be done by the research student who will use these findings to inform future research to be undertaken as part of a PhD research programme. If you would like to be kept informed about the research presentations/publications arising from this research please indicate this on your consent form and we'll let you know in due course.

What if something goes wrong?

It is very unlikely that something will go wrong during this research. However, you should know that the university has procedures in place for reporting, investigating, recording and handling what are called adverse events.

Any complaints will be taken seriously and should be made, in the first place, to the Chief Investigator, Dr Alyson Hill (contact details at end).

Further information of the University's complaints procedure can be found at:
<http://www.ulster.ac.uk/quality/qmau/complaints.html>

The University is insured for its staff and students to carry out research involving people. The University knows about this research project and has given permission for it to proceed. Further details can be found in the University's research indemnity statement which is available on request.

Will my taking part in this project be kept confidential?

Yes. All the information that we collect about you during the focus group will be kept strictly confidential. Focus group will be recorded digitally and stored as digital files in password protected folders on a University computer. All data will be destroyed using confidential waste policy within Ulster University after the study ends.

What will happen to the results of the study?

The results of this study will be used to develop the contents of further intervention study aiming to improve healthy eating among university students. The research will also be written up and presented in a number of forums, both within the University (e.g. research presentations in the departments in which the research has been carried out) and to the national/international teaching and research community. The writing-up and presentations will be done by the research student working on the project. If you would like to be kept informed about the research presentations/publications arising from this research please indicate this on your consent form and we'll let you know in due course.

Who is organising and funding the research?

The qualitative study is supported by Researchers at Northern Ireland Centre for Food & Health (NICHE), within the School of Biomedical Sciences at Ulster University.

Who has reviewed this study?

This study has been reviewed by Dr Alyson Hill and Prof Alison Gallagher. It has also been reviewed by peers knowledgeable in the conduct of scientific research and Ulster University, School of Biomedical Ethics Filter Committee.

Thank you for taking time to read this information

More information or complaints?

If you would like more information about this research please contact:

Mr	Amin	Hafiz	(PhD	student)
Email:			<u>Hafiz-A2@email.ulster.ac.uk</u>	

Supervisors		contact:
-Dr	Alyson	Hill
E-mail:	<u>aj.hill@ulster.ac.uk</u>	

-Prof Alison Gallagher
E-mail: am.gallagher@ulster.ac.uk

Appendix 4 Questionnaires and consent form Chapter 4

Screening questionnaire

My name is Amin Hafiz, a PhD student in Human Nutrition based within NICHE Ulster University. I am undertaking research using Facebook to increase fruit and vegetable consumption of students: If you are interested in participating, please complete this short questionnaire. All responses are anonymous and will only be used for the purposes of this research study.

If you would like any further information regarding this study please contact me by email (Hafiz-A2@email.ulster.uk) or my supervisors Dr Alyson Hill (aj.hill@ulster.ac.uk) and Prof Alison Gallagher (am.gallagher@ulster.ac.uk)

1: What is your age?

_____ years

2: What is your gender?

Male ☐

Female ☐

Other ☐

Prefer not to say ☐

3: What is your nationality?

British/Irish/UK ☐

Other European ☐

Non-European ☐

4: What best describes your present living arrangements?

Living with own family ☐

Living in Single accommodation ☐

Living in Shared accommodation ☐

Other _____

5: What year of degree study are you in? Please tick

Year	BSc	PgD/MSc	PhD
1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6: What is the title of the course you are studying?

7: Which campus are you attending?

Coleraine ☐

Belfast ☐

Jordanstown ☐

Magee. ☐

8: Do you use any social networks?

Yes ☐

No ☐

a: If yes, How regularly do you use social networks?

b: If yes, what types of social network do you use? (e.g. Facebook, Twitter, Instagram, Snapchat, etc)

9: Do you have any medical condition?

Yes ☐

No ☐

a: If yes, what is the medical condition? (e.g. diabetes, coeliac disease)

b: Do you have any eating disorders? (e.g. anorexia nervosa, Bulimia nervosa, Binge-eating disorder)

Yes ☐

NO ☐

10: Do you follow a special diet?

Yes ☐

No ☐

a: If yes, what type of special diet?

-Vegetarian/vegan

- Gluten free

-Other _____

11: Are you currently pregnant/ planning a pregnancy?

☐☐

Yes

No

12: Are you taking/ planning on taking a supplement containing Vitamin C or Vitamins ?

Yes ☐ If yes please list name_____

☐ No

13: How many portions of fruit and vegetables do you usually consume each day day? (A portion equals 1 medium apple, small banana, 6-10 strawberries 3 heaped tablespoons of peas, 2 broccoli spears).

-1 portion a day or less ☐

-4 portions a day ☐

-2 portions a day ☐

-5 portions a day ☐

-3 portions a day ☐

-More than 5 portions a day ☐

14: If you have any special medical needs, please specify?

If you would like to participate in the study above, please contact me Hafiz-A2@email.ulster.ac.uk or telephone 02870124128

Mr Amin Hafiz PhD student Room number CMB W2041

**Chief Investigator:**

Dr Alyson Hill
028-7012-4128
aj.hill@ulster.ac.uk

Researcher:

Amin Hafiz
028-7012-3529
Hafiz-a2@email.ulster.ac.uk

Consent Form for studies involving the use of human tissue/relevant material

Title of Study

Increasing fruit and vegetable consumption in University students: A randomised controlled study.

Chief Investigator

Dr Alyson Hill

Please confirm, by marking the boxes, that you agree with the following statements:

1. I have been given and have read and understood the information sheet (V2, 31-10-2016) for the above study and have asked and received answers to any questions raised ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without my rights being affected in any way ☐
3. I understand that the researchers will hold all information and data collected during the study securely and in confidence and that all efforts will be made to ensure that I cannot be identified as a participant in the study (except as might be required by law) and I give permission for the researchers to hold relevant personal data ☐
4. I understand that my blood are required for the purposes of this study and confirm that I have been given details of the amount(s) to be taken and how it will be stored, used and the method of disposal ☐
5. I agree to take part in the above study ☐

6. The potential benefits of keeping my blood for future research studies have been explained to me and (please read carefully and choose ONE):

a. I consent to their indefinite storage and use in any University-approved future study,

☐

OR

b. I consent to their indefinite storage and use in any University-approved future study that does not involve the use of my genetic material;

☐
☐

OR

c. I do not wish my blood or tissues to be used for any purpose other than this study

Name of Participant (please print)

Signature

Date (dd/mm/yy)

Name of Researcher

Signature

Date (dd/mm/yy)



Increasing fruit and vegetable consumption in University students: A randomised controlled study.

DIETARY QUESTIONNAIRE

MEAL PROFILE

Subject ID no. _____

Breakfast Profile:

Breakfast Menus - Week Days	
Day 1	
Time: _____	
Day 2	
Time: _____	
Breakfast Menus - Week-End Days	
Day 1	
Time: _____	

Day 2 Time: _____

Mid-Day Meal Profile:

Mid-Day Menus - Week Days
Day 1 Time: _____
Day 2 Time: _____

Mid-Day Menus - Week-End Days**Day 1**

Time: _____

Day 2

Time: _____

Evening Meal Profile:

Evening Meal Menus - Week Days**Day 1**

Time: _____

Day 2

Time: _____

Evening Meal Menus - Week-End Days**Day 1**

Time: _____

Day 2

Time: _____

Tea / Coffee Breaks and Snacks

Week Days			
	Morning	Mid-Afternoon	Evening
Day 1	Time: _____	Time: _____	Time: _____
Day 2	Time: _____	Time: _____	Time: _____
Week-End Days			
	Morning	Mid-Afternoon	Evening
Day 1	Time: _____	Time: _____	Time: _____
Day 2	Time: _____	Time: _____	Time: _____

Check recall for :
Alcohol

Sweets

Vitamins

Yoghurt

Portion size estimationCup ☐Small bowl ☐Small mug ☐Shallow bowl ☐Large mug ☐Deep bowl ☐Small glass ☐Tall glass ☐

80-g serving of fruits = e.g. (one medium apple) or (one medium orange) , (or one medium banana),

80-g serving of vegetables = e.g. (3 heaped tablespoons of peas) or (2 broccoli spears)

Recipes and tips on Facebook:

Week1

Day 1 General Health Benefits of FV

Always remember the old adage '*you are what you eat*'

-Skin: Eating FV helps to nourish your skin and make it radiant and beautiful.
<http://www.bbcgoodfood.com/howto/guide/eat-your-way-fabulous-skin>

-Energy: Are you feeling not energetic in the morning and losing your energy during the day. Some of fruit and vegetables will boost your energy level

<http://www.bbcgoodfood.com/howto/guide/how-eat-more-energy-0>

-Bones: Fruit and vegetables also have bone boosting benefits

<https://www.nof.org/patients/treatment/nutrition/>

-Fruits and vegetables are important for good health and packed with essential vitamins and minerals .

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

Day 2 General Health Benefits of FV and tips

Are you aware how much of fruits and vegetables you should eat and what counts as a portion?

Have a try and test your knowledge before reading the information below. Please don't forget to send me your score.

<http://www.popsugar.com/fitness/Quiz-About-Fruit-Vegetable-Intake-3007029>

-You should eat at least five (80g) portions (at least 400g in total) of a wide variety fruit and vegetables a day – about a third of your total daily food consumption

-One portion is 80g or any of the following:

Fruit

- *One banana, orange, pear or apple or a similar sized fruit*

- *Half a large grapefruit or avocado*
- *A slice of large fruit such as melon or pineapple*
- *Two satsumas, plums or similar sized fruit*
- *A handful of grapes, cherries or berries*
- *One heaped tablespoon of dried fruit (such as raisins and apricots or three heaped tablespoons of*
fruit salad (fresh/tinned in fruit juice) or stewed fruit

Vegetables

- Three heaped tablespoons of vegetables (raw, cooked, frozen or tinned)
- Three heaped tablespoon of any 'pulse' – beans, peas or lentils (however much you eat, pulses only count as one of your five-a-day)
- One dessert bowl of salad

<http://www.bbc.co.uk/news/health-26818386>

<http://www.safefood.eu/Healthy-Eating/What-is-a-balanced-diet/The-eatwell-plate/Fruit-and-vegetables.aspx>

Try this it's tasty. Snack: dip chopped raw vegetables to hummus or fruit to peanut butter

<http://www.bbcgoodfood.com/recipes/peanut-houmous-fruit-veg-sticks>

<http://www.bbcgoodfood.com/recipes/peanut-houmous-fruit-veg-sticks>

Day 3

Let's have some nutritional tips for the weekend

-Add fruit to cereal, porridge or lower fat yoghurt – e.g., a handful of berries is lovely.

<http://www.safefood.eu/Healthy-Eating/What-is-a-balanced-diet/The-eatwell-plate/Fruit-and-vegetables.aspx>

-**Grilled salmon or chicken cutlets:** Peel and dice the carrot and boil it with broccoli.

Served together (<http://www.safefood.eu/Healthy-Eating/Recipes/Dinner/Grilled-salmon-cutlets.aspx>) Ingredients

-

Week2

Day1

Do you know that by eating fruits and vegetables you are protecting your health and optimizing your immune system?

-People who eat plenty of fruit and veg have a lower risk of developing many diseases, including high blood pressure, obesity, heart disease and stroke, and some cancers (including mouth, throat, stomach, colon and lung cancers)

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>.

-Fruits and vegetables is the second most important cancer prevention strategy, after stopping smoking

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

day2

Nutritional facts & Tips to get your five-a-day



-**Eat a rainbow:** Variety is important, as different coloured fruits and vegetables contain their own combination of vitamins and minerals, so try to eat one portion from each colour group

BBC: <http://www.bbcgoodfood.com/howto/guide/easy-ways-7-day>

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

-Try this as a Starter -Raw vegetables with a garlic mushroom sauce.

<http://www.bbcgoodfood.com/recipes/10171/creamy-garlic-mushrooms>

Week3 Information on buying and cooking fruit and vegetable tips to increase the intake.

Day 1

When you buy Fruit and vegetables go for those in season: Opting for fresh produce as they are more likely to be locally grown, are value for money and often look and taste the best

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

What fruit and vegetable are in season? Have a look

<http://www.fruitsandveggiesmorematters.org/what-fruits-and-vegetables-are-in-season>

<http://www.bbcgoodfood.com/seasonal-calendar/all>

Tips of the day

-Try a bowl of wholegrain breakfast cereal with a sliced banana and a glass of pure fruit juice.

-Try banana pancakes for breakfast instead of cereal

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

<http://www.bbcgoodfood.com/recipes/banana-pancakes>

Day 2

The best method of cooking fv is ?

-Best cooking methods: Fruit and vegetables can be easily destroyed during food preparation and by heat, so whenever possible eat raw. When cooking vegetables, try steaming, microwaving or poaching rather than boiling, so the maximum amount of nutrients can be retained.

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

<http://www.fruitsandveggiesmorematters.org/top-10-healthy-ways-to-cook-fruits-and-vegetables>

Tips to increase your five a day

- Add some crunch to your sandwiches with cucumber, grated carrot or tomato, and have a piece of fruit for dessert.

- Simple raspberry smoothie - raspberries

<http://www.safefood.eu/Healthy-Eating/Recipes/Breakfast/Simple-smoothie-raspberry-and-banana.aspx>

Day 3

It's a weekend why not to try some cooking skills, try this

- Homemade fruity nutty muesli

<http://www.safefood.eu/Healthy-Eating/Recipes/Breakfast/Homemade-fruity-nutty-muesli.aspx>

- Grilled vegetable with kebab/pri pri chicken and add olive oil and lemon.

<http://nutritionstripped.com/simple-grilled-vegetable-skewers/>

Week4 Information and tips to increase fruits and vegetables intake

Day 1

Be careful from some fruits?

You can also eat dried fruit, but not too much as it **high in sugar**.

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

Challenge yourself to include a portion of vegetables in every dish you prepare/eat, add chopped carrots, onion, celery, garlic to spaghetti Bolognese.

http://www.bbc.co.uk/food/recipes/healthyspaghettibolo_80401

Try butternut squash spaghetti

<http://www.eatingwell.com/recipes/21947/ingredients/vegetables/squash/winter/butternut/>

Day2

Keep in mind that canned and frozen fruit and vegetables count as your 5 a day

-For an easy way to your 5 A DAY, add canned, frozen or fresh vegetables to your meals to make them even tastier and go further too:

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

5 a day tips of the weekend:

- Sprinkle pepper, onion, mushroom, sweetcorn or pineapple chunks on top of a thin-based pizza.

<http://www.nhs.uk/change4life/pages/five-a-day-every-day.aspx>

Week5

Day 1

Instructions to Store your fruit and vegetables for a longer time with Best Flavour

Do you know where to store your fruit and vegetable for best result and Flavour? Have a look

http://www.huffingtonpost.co.uk/entry/how-to-store-your-fruit-and-veg-to-make-it-last-longer_uk_5715e9ace4b0636a3f6d1b2d

Good food

- Have a salad or veg with your main meal.

<http://www.safefood.eu/Healthy-Eating/What-is-a-balanced-diet/The-eatwell-plate/Fruit-and-vegetables.aspx>

- If it's a roast dinner, make sure you've got some veg on your plate. Try carrots, broccoli, beans, peas.

<http://www.nhs.uk/change4life/pages/five-a-day-every-day.aspx>

French toast with ricotta and your choice of fruits: French toast can be served with all sorts of fruit and nuts why not to try it. Also, Use avocado rather than mayo in your sandwich/ toast

<http://www.safefood.eu/Healthy-Eating/Recipes/Breakfast/French-toast-with-ricotta-and-berries.aspx>

<http://www.bbcgoodfood.com/recipes/collection/healthy-sandwich>

Day 2

snack tips and being out and about

-For takeaway add vegetables to your meal e.g broccoli, spinach to pizza.

<http://www.safefood.eu/Healthy-Eating/What-is-a-balanced-diet/The-eatwell-plate/Fruit-and-vegetables.aspx>

Why not make your own fruit yoghurt using natural yoghurt and your favourite fruit. Add fruits (if e.g. blueberries aren't your thing, you could also try raspberries, strawberries or blackberries; fresh, frozen alone or together to low fat yogurt.

(<http://www.safefood.eu/Healthy-Eating/Recipes/Breakfast/Crunchy-blueberry-yoghurt.aspx>)

Day 3

-Add to your favourite salad fruits such as blueberry, strawberry and melon.

-Lunch : quinoa salad: Try to add watermelon & spinach to quinoa super salad.

<http://www.bbcgoodfood.com/recipes/watermelon-spinach-super-salad>

Week6 Only tips

Day 1

-Lunch during studying/university time

- Tuna salad: add raw leafy vegetables to tuna.

<http://www.bbcgoodfood.com/recipes/collection/tuna>

- Chicken salad with apple pieces and grapes is delicious.

<http://www.eatingwell.com/recipe/250282/chicken-waldorf-salad/>

Add your vegetables to any sandwich or panini.

<http://www.safefood.eu/Healthy-Eating/What-is-a-balanced-diet/The-eatwell-plate/Fruit-and-vegetables.aspx>

-Ditch the biscuits for fresh melon slices

<https://www.bda.uk.com/foodfacts/FruitVeg.pdf>

Day 2

-Add vegetables (e.g. Spanish) to omelette.

<http://www.bbcgoodfood.com/recipes/2685647/spanish-omelette>

Week7 Only tips**Day 1**

-Add your vegetables raw or cooked on pasta.

- Add vegetables to pasta sauce, stews and soup e.g. Broccoli or spinach to baked pasta.
Delicious

<http://www.nhs.uk/change4life/pages/five-a-day-every-day.aspx>

Day2

-Mix your choice of fruits (e.g. cherry or blueberry) to celery.

<http://www.safefood.eu/Healthy-Eating/Recipes/Snacks/Ants-on-a-log.aspx>

-Put cinnamon and low fat cheese on apples and bake it.

<http://www.nhs.uk/change4life/pages/five-a-day-every-day.aspx>

Day3

Make a veggie wrap with roasted vegetables and low-fat cheese rolled in a whole-wheat tortilla.

<http://www.eatright.org/~media/eatright%20files/nationalnutritionmonth/handoutsandtipsheets/nutritiontipsheets/20waystoenjnymorefruitsandvegetables.ashx>

Try crunchy vegetables instead of chips with your favorite low-fat salad dressing for dipping.

<http://www.eatright.org/~media/eatright%20files/nationalnutritionmonth/handoutsandtipsheets/nutritiontipsheets/20waystoenjnymorefruitsandvegetables.ashx>

Grill colorful vegetable kabobs packed with tomatoes, green and red peppers, mushrooms and onions.

<http://www.eatright.org/~media/eatright%20files/nationalnutritionmonth/handoutsandtipsheets/nutritiontipsheets/20waystoenjnymorefruitsandvegetables.ashx>

Keep cut vegetables handy for mid-afternoon snacks, side dishes, lunch box additions or a quick nibble while waiting for dinner. Ready-to-eat favorites: red, green or yellow peppers, broccoli or cauliflower florets, carrots, celery sticks, cucumbers, snap peas or whole radishes.

Place colorful fruit where everyone can easily grab something for a snack-on-the-run. Keep a bowl of fresh, just ripe whole fruit in the center of your kitchen or dining table.

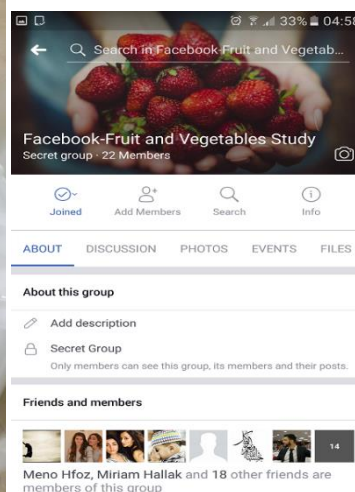
<http://www.eatright.org/~media/eatright%20files/nationalnutritionmonth/handoutsandtipsheets/nutritiontipsheets/20waystoenjnymorefruitsandvegetables.ashx>

Photos of the method

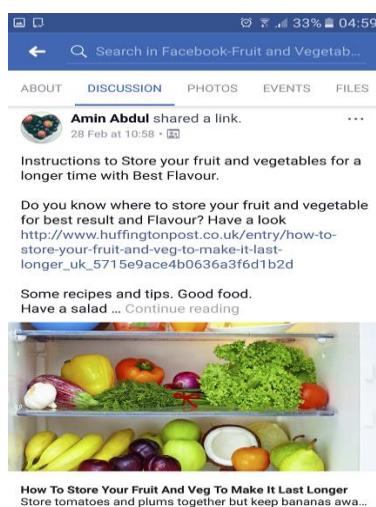
1A: Preparation of F&V



1C: Return bags & waste 1D: Example of FB private page



1B: Packing F&V in cold bags 1E: Example of FB posts 1F: Example of participant's engagement with FB page



Appendix 5 Conferences and Publication to date**Abstract**

The influence of social networks education in increasing fruit and vegetables consumption in university students: a randomised controlled study By A.A. Hafiz¹, A.M. Gallagher¹ and A.J. Hill¹, ¹*Nutrition Innovation Centre for Food and Health, Ulster University, Coleraine BT52 1SA, UK*

Despite the benefits of fruit and vegetables (F&V) consumption on health, university students face difficulties adapting and/or maintaining a healthy lifestyle when living away from home. Adverse health-related behaviours are prevalent in this population⁽¹⁻³⁾ which potentially impact on longer-term health beyond young adulthood⁽⁴⁾. The present study aimed to 1) increase fruit and vegetable consumption in students living away from home, and 2) to determine whether F&V consumption was further enhanced when social networks (e.g. Facebook) providing nutritional education was also available.

A total of 60 (36 female 24 male) full-time university students living away from home were recruited and randomly allocated to one of 3 study groups, namely: 'Control' received no intervention, 'F&V' received two and three fruits and vegetables respectively for 4 weeks from an individualised preferred list, and the 'F&V + Education' received F&V (as for the F&V group) plus nutrition education delivered via Facebook and which focused on benefits of F&V consumption. Consumption of F&V was assessed pre-intervention using a validated questionnaire and post intervention using a 4 day semi-quantitative food diaries. Compliance relating to consumption of F&V provided was assessed using records of waste/uneaten F&V. Analysis of food diaries was undertaken using Nutritics software and SPSS version 24 used for statistical analysis. All data were log-transformed before statistical analysis using Paired sample t-test and ANOVA.

Table. Mean daily portions of F&V consumed and change in intake by intervention groups.

Daily portions of F&V	Control group (n=20)	<i>P</i>	F&V group (n=20)	<i>P</i>	F&V + Education group (n=20)	<i>P</i>
Food-diary¹						
Pre (baseline)	1.5 (0.5)	0.287 ¹	1.7 (0.4)	<.0001 ^a	1.6 (0.5)	<.0001 ^a
Post (4 weeks)	1.6 (0.4)		3.8 (1.1)		3.7 (1.7)	
ΔF&V ^b	0.1 (0.5)		2.2 (1.2)		2.2 (1.5)	
Return bags²						
Pre (baseline)	NA	-	1.7 (0.4)	<.0001 ^a	1.6 (0.5)	<.0001 ^a
Post (4 weeks)	NA		4.6 (0.6)		4.7 (0.4)	
ΔF&V ^c	NA		2.8 (0.7)		3.0 (0.6)	0.373 ^c

F&V, Fruit and Vegetable; ΔF&V, Post minus Pre intake; NA, not applicable. Values are mean (SD) for F&V portions reported from ¹food-diary or ²return bags. ^aPre versus post intervention intake compared using paired Sample t-test. ^bChange in F&V intake compared across groups using ANOVA. ^cChange in F&V intake compared across groups using an independent t-test.

Participants at baseline were mean age 24.4y (SD 3.7) y, BMI 25.4 (SD 4.7) kg/m² and study groups did not differ by age. Consumption of F&V increased in both intervention groups (*P*<.0001, see Table) from baseline to end of study with food diary data suggesting that 31% of participants in both intervention groups consumed 5 portions of F&V each day. However in

contrast data from 'return bags' suggested 65% achieved this in both intervention groups. 70% of participants engaged with Facebook regularly. In conclusion, this study showed that providing F&V weekly increased consumption in university students and providing additional nutrition education (via Facebook) did not further enhance intakes of F&V. Further work is currently underway to assess biomarkers of F&V intake to objectively assess F&V intakes during the study period and to determine whether continuing the nutrition education component can help sustain these changes in F&V intakes.

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A technology based nutritional education intervention to increase fruit and vegetables consumption in university students: a randomised controlled study By A.A. Hafiz¹, A.M. Gallagher¹ and A.J. Hill¹, ¹*Nutrition Innovation Centre for Food and Health, Ulster University, Coleraine BT52 1SA, UK*

The transition from post primary school to tertiary education has been recognised as a vulnerable period regarding the development of unhealthy eating behaviours of university students that may have long-term health implications lasting well into adulthood⁽¹⁻³⁾. Evidence from surveys in USA and UK have shown that the typical university student's diet is generally low in fruits and vegetables which leads to poor nutritional intake and weight gain⁽³⁻⁴⁾. The present study aimed to 1) increase F&V intake in university students, and 2) to determine whether F&V intake was further enhanced when nutritional education was also provided via a closed-Facebook page.

A 60 full-time university students (36 female 24 male) were randomly assigned to one of 3 arms, namely: *Control group*, received no intervention; *F&V group* received two and three portions fruit and vegetables respectively for 4 weeks from an individualised preferred list; and *F&V + Facebook group* received F&V (as for the F&V group) plus nutrition education delivered via Facebook and which focused on benefits of F&V consumption. Level of engagement on FB page was determined by for example participants who interact at least once per week was categorized as highly active, somewhat active (interacts >once per month) or minimally active (interacts <once per month). Consumption of F&V was assessed by a researcher pre and post intervention using a validated 4 day semi-quantitative food diaries. Compliance relating to consumption of F&V provided was assessed using records of waste/uneaten F&V. Analysis of food diaries was undertaken using Nutritics software and SPSS version 24 used for statistical analysis. All data were log-transformed before statistical analysis using Paired sample t-test and ANOVA.

Variables	Control group (n=20)	F&V group (n=20)	F&V + Education group (n=20)	P
Age (Years)	24.9 (3.2)	23.6 (3.8)	24.7 (4.1)	0.489 ^a
TEI (Kcal/d)	1296 (257)	1409 (309)	1540 (323)	0.041^b
BMI (kg/m ²) baseline	27.6 (4.2)	24.6 (5.8)	24.1 (3.1)	0.039^c
Level of engagement in Facebook Page				
group	Intervention period (4 weeks)	Follow up period (3 weeks)	P	
F&V + Facebook group (n=20)	49 (3.8)	25.5 (3.3)	<.0001 ^d	

F&V, fruit and vegetables; TEI total energy intake; Values are mean (SD) for all variables. ^{a,b,c} Difference in mean age and BMI at baseline and total energy intake at the end of 4 weeks intervention period compared across groups

using one way ANOVA. ^d Difference in mean of level of engagement by post in Facebook page using paired sample T test.

70% of participants engaged with Facebook regularly with 35% classified as highly active, 15% somewhat active and 50% minimally active. Consumption of F&V increased in both intervention groups ($P<.0001$) from baseline to end of study with food diary data suggesting that 31% of participants in both intervention groups consumed 5 portions of F&V each day. However in contrast data from 'return bags' suggested 65% achieved this in both intervention groups. In conclusion, this study showed that providing F&V weekly increased consumption in university students and providing additional nutrition education (via Facebook) did not further enhance intakes of F&V.

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The efficacy of Facebook in increasing fruit and vegetables consumption in university students: a randomised controlled study By A.A. Hafiz¹, A.M. Gallagher¹ and A.J. Hill¹,

¹*Nutrition Innovation Centre for Food and Health, Ulster University, Coleraine BT52 1SA, UK*

Despite the benefits of fruit and vegetables (F&V) intake on health, university students may struggle to adopt and/or maintain a healthy lifestyle when living away from home. Adverse health-related behaviours are prevalent in this age group⁽¹⁻³⁾ which potentially impact on longer-term health beyond young adulthood⁽⁴⁾. The present study aimed to 1) increase F&V intake in university students, and 2) to determine whether F&V intake was further enhanced when nutritional education was also provided via a closed-Facebook page.

A total of 60 (36 female, 24 male) full-time university students living away from home were recruited and randomly assigned to one of 3 study groups, namely: *Control group*, received no intervention; *F&V group* received two and three portions fruit and vegetables respectively for 4 weeks from an individualised preferred list; and *F&V + Education group* received F&V (as for the F&V group) plus nutrition education delivered via Facebook and which focused on benefits of F&V consumption. Consumption of F&V was assessed pre-intervention using a validated questionnaire and post-intervention using a 4-day semi-quantitative food diaries. Compliance relating to consumption of F&V provided was assessed using records of F&V not consumed and left in the return bags. Analysis of food diaries was undertaken using Nutritics software and SPSS version 24 used for statistical analysis. All data were log-transformed before statistical analysis using Paired sample t-test and ANOVA.

Daily Portions of F&V

	Pre(baseline)	Post(4weeks)	<i>P</i>	ΔF&V ^b	<i>P</i>
Food-diary¹					
Control group (n=20)	1.5 (0.5)	1.6 (0.4)	0.287 ^a	0.1 (0.5)	
F&V group (n=20)	1.7 (0.4)	3.8 (1.1)	<.0001 ^a	2.2 (1.2)	<.0001 ^a
F&V + Education group (n=20)	1.6 (0.5)	3.7 (1.7)	<.0001 ^a	2.2 (1.5)	
Return bags²					
Control group (n=20)	NA	NA		NA	
F&V group (n=20)	1.7 (0.4)	4.6 (0.6)	<.0001 ^a	2.8 (0.7)	0.373 ^c
F&V + Education group (n=20)	1.6 (0.5)	4.7 (0.4)	<.0001 ^a	3.0 (0.6)	

F&V, Fruit and Vegetable; ΔF&V, Post minus Pre intake; NA, not applicable. Values are mean (SD) for F&V portions reported from ¹food-diary or ²return bags. ^aPre versus post intervention intake compared using paired Sample t-test. ^bChange in F&V intake compared across groups using ANOVA. ^cChange in F&V intake compared across groups using an independent t-test.

Participants at baseline were mean age 24.4y (SD 3.7) y, BMI 25.4 (SD 4.7) kg/m² and study groups did not differ by age. Consumption of F&V increased in both intervention groups (*P*<.0001) from baseline to end of study with food diary data suggesting that 31% of participants in both intervention groups consumed 5 portions of F&V each day. However in contrast data from 'return bags' suggested 65% achieved this in both intervention groups. 70%

of participants engaged with Facebook regularly. In conclusion, this study showed that providing F&V weekly increased consumption in university students and providing additional nutrition education (via Facebook) did not further enhance intakes of F&V. Further work is currently underway to assess biomarkers of F&V intake to objectively assess F&V intakes during the study period and to determine whether continuing the nutrition education component can help sustain these changes in F&V intakes.

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A qualitative study to explore the experiences of university students which influence eating behaviours when living away from home. By A.A. Hafiz¹, A.M. Gallagher¹ and A.J. Hill¹, ¹*School of Biomedical Sciences and Northern Ireland Centre for Food and Health, Ulster University, Coleraine BT52 1SA, UK*

The transition from post-primary school to tertiary education has been recognised as a vulnerable period regarding the development of unhealthy eating behaviours of students who leave home and move to university⁽¹⁾. Many students struggle to adapt a healthy lifestyle as they, become more independent, are influenced by new peers, have limited finances^(2,3). Thus, dietary behaviours of university students may have long-term health implications lasting well into adulthood⁽⁴⁾. The aim of this qualitative study was to explore the eating behaviours and experiences of university students in Northern Ireland who regularly live away from home.

Full-time students living away from home for a minimum of 4 nights each week were recruited following a university wide e-mail. European and non-European students, including undergraduate and postgraduate students in all study disciplines/subjects who responded, were invited to participate in a facilitated group discussion using a semi-structured interview schedule. All group discourse was audio-taped, transcribed verbatim and analysed using thematic analysis for common themes. Data were analysed using NVivo 10.

Forty two students (n= 27 male; 15 female), both undergraduate (n=17) and postgraduate (n=25) students, participated in 8 facilitated discussions; mean age 23 (SD 5.3), years mean BMI 24.5 (SD 4.6) kg/m². Three key themes were identified to influence eating behaviours. Firstly, *nutritional awareness and knowledge*: Lack of cooking and menu preparation skills. Secondly, *personal factors*: time and convenience, finance, past habits strength, peer influence and perceived enjoyment. Finally, *physical factors*: food availability, accessibility, cooking facilities, exam stress/pressures. These key themes together with student recommendations and ideas arising from this focus group work are being used to facilitate the development of an effective and tailored intervention programme aimed at influencing eating behaviours in university students living away from home in Northern Ireland.

This study was carried out with financial support from the Royal Embassy of Saudi Arabia

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